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A QUARTERLY MISCELLANY OF ENTERTAINING & INSTRUCTIVE ARTICLES ON SCIENTIFIC SUBJECTS.

EDITED BY JAMES SAMUELSON,

AUTHOR OF "THE EARTHWORM AND HOUSEFLY," "HONEY-BEE," ETC.

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CAVERNS AND THEIR CONTENTS.

BY D. T. ANSTED, F.R.S.

Chapter I.

THE CAVERNS.

ONE of the great charms of a wild ramble by the sea-side, where the cliffs and the waves occasionally meet, and where the tidal action is powerful enough to produce a marked impression on the form of the shore, is, that we are thus constantly presented with varied broken outlines whose picturesqueness depends on rock, wind, and weather. But within these outlines are frequently deeper recesses, more or less concealed, more or less difficult of access, more or less occupied by animal or vegetable life, or the remains of such life, and into their cavernous recesses one is always tempted to penetrate, for in them we rarely fail to find grand and simple forms:—rocky vaults arched according to some fantastic plan of Nature's own device; sepulchres yielding occasionally bones of very ancient lords of the soil, and collections of living animals of low organization, especially interesting because capable of being observed under natural conditions.

Few rocks so situated on a bold coast are without caverns; but there are two large and very easily recognized kinds of material in which caverns chiefly occur. These are granite and limestone. The best caverns in every respect are in one or other of these rocks; but they vary in their nature, origin, and history, to a remarkable extent.

The first commencement of almost all caverns may generally be traced either to mechanical disturbance connected with the upheaval of rocks formed at great depth, and subsequently brought to their present position, near the surface of the earth, or else to that contraction which has of necessity taken place when materials deposited in and with water have solidified, parting with their water, and contracting into a smaller space, as they ceased to be mud and became compact rock.

Cracks and fissures, either originally open, or closed almost as soon as formed by the introduction of mineral substances, that decompose on exposure to weather more rapidly than the rocks enclosing them, are thus the fertile causes of most of those innumerable natural holes and fastnesses of which poets

sing and which artists love to represent. Varying in their origin according to the nature of the rock they lay open for our inspection, and indicating the history and progress of the changes they have undergone before arriving at their present state, they have a special interest for the geologist; and it is astonishing how completely geological points regulate also their value and interest to the naturalist, the artist, and the mere seeker after adventure and picturesque scenery.

First let us consider the case of caverns in those noble old granites and porphyries, those gneissic rocks, those slates, and those basaltic and volcanic regions where the battle is ever going on between the dash of the wave and the tough fibre of a hard rock. It is a battle that can end only in one way, for, unlike all human contests, in which both sides suffer, the water, however often beaten back, always comes again to the charge unweakened by the effort—it always finds at last the weak point in the enemy's armour—each time it succeeds in removing a few grains or fragments, it enlists these as recruits to bring away more—and thus it advances steadily if stealthily—surely if slowly—"here a little and there a little," until very often it is enabled to act on a larger scale and assume a more important attitude of offence.

Look at the "iron-bound" shores of the Atlantic on the European side. Take any part of this extended line where the granite is firmest and the porphyry toughest. How do we find these rocks? Many of the hardest are islands, already detached from the main land, many others are headlands and promontories. Between them and amongst them are lovely little bays with sandy and rocky beaches. The cliffs exposed are hoary enough to look at, and covered with lichens. But what mean the angular blocks of stone on the beach? Whence came those vast fallen masses almost like islands, at the foot of the cliff? The question is easily answered. They have fallen from above. The cliff has been undermined, the ruin and destruction of the whole mass long ago commenced, and there is no longer any question but that of the time that will be required to complete the work.

The study of a single island, or even part of an island, is very instructive, and the account of a single group of caverns will be more satisfactory than a long description of varied disturbance.

There is in the English Channel a wonderful little island, three miles long, and a mile and a half across at the widest part, entirely surrounded by steep cliffs, some 250 or 300 feet high, the whole of which, without exception, are composed of granitic and porphyritic rock. One would say, looking at the walls of rock surrounding it, that the waves, angry and

powerful as they might be, would here have little effect. They must beat against this granite in vain. Except here and there, where a soft vein occurs, the rock is all hard. There is no mixture of modern water-deposited limestone or sandstone—no beds of yielding clay and treacherous sand—no loose rocks or decomposable material. All is granite, or hornstone, or porphyry, or some of those other rocks recognized by geologists as among the most indestructible. But what is the fact? Of all places within easy access there is none like Sark for caverns—nowhere is the history of the origin and enlargement of one great class of caverns more manifest—nowhere is granite more clearly the slave of water, performing all its behests, helping to subjugate completely the very class of rocks to which it belongs, the broken rocks themselves working incessantly and actively with the waves, helping to tear into shreds and carry away as mud and sand all that is hardest and most durable.

Caverns in granite are generally water-worn from without, or, in other words, the mechanical force of the waves is greater than the dissolving and chemical action of fresh water percolating the rocks. Always, no doubt, a solvent, the effect of water in this respect on rocks which contain but little alkaline earths is comparatively small; but, on the other hand, such rocks, having been originally formed at high temperature and cooled down, have cracked, and the cracks have become filled with various mineral substances, often decomposing more or less readily than the rock. It is not difficult to understand that the effect of this difference of condition must involve a partial and irregular destruction of the rock. The softer part being removed, the harder part falls down, and thus we have those never-ceasing little bays, creeks, and inlets, those wonderful *voes* and *fiords*, and other variously named irregularities of the coast-line, which greatly contribute to the wildness and grandeur of granite coast scenery.

And thus also we have caverns formed. On that part of a group of hard rocks that is softer than the rest, the water first acts. It beats vehemently against the rock with a force sometimes of many pounds on the square inch. On an exposed coast blocks of stone weighing two or three tons, and presenting more than eight or ten square feet of surface, are lifted up and carried over obstacles to a great distance. Smaller stones are rolled about and hammered against each other, and against every weak place in the cliff. After a time, the weak place is hollowed out, and an open cave is the result. Two or three veins, parallel to each other, are acted on in this way, perhaps at the same time, and an entry is made. The commencement of a tunnel is driven, a tunnel that shall connect

the waters of adjoining bays, just as that now in progress through the Mont Cenis will connect France with Italy. Neither operation is work that shows much advance from year to year, but of both the result is sure. Great systems of veins, parallel and at right angles to each other, are acted upon, and the tunnel creeps on. At the same time, perhaps, a little rill of water insidiously makes its way from above, finding some means of coming down to the sea below. Very soon does the sea take advantage of this slight help. It is the mouse gnawing the meshes of the net that holds the lion. A part of the ground above falls in, and either a rapid slide of part of the cliff, or a gradual and periodical fall of the roof, gives the sea something to remove, and supplies fresh hammers wherewith to beat at the outer gate. The cavern enlarges as the walls and roof recede,—falling to the floor, and removed thence by the waves.

Thus have been formed those magnificent caverns in Sark, called "Les Boutiques," than which few things are finer; thus, also, were formed the "Gouliot" caves in the same island.

The walls of such caverns are generally bare and smooth—worn so by the constant trituration of small stones conveyed by the sea. They are sometimes also deeply furrowed with fissures, not yet expanded. It is only where the tide rises and falls many yards that such results are seen on a grand scale; but according to the extent of force exerted, so will be the destruction.

Large caverns that enter far into the land, whose floors were originally level with the sea, become by degrees altered in this respect, when the roof falls in faster than the sea is able to grind up and remove the fragments. Then we often have one access to the cavern half-way down a steep face of rock, and the floor rises until at last there is a mere open cleft above, and no more roof remains to fall. The cavern is then open to the sky, and is a kind of natural chimney. The work of the sea, however, goes on steadily from below, and at last the fallen fragments are removed: the gap or chimney then enlarges, the cavern at last ceases to exist, and what was once part of the mainland, forming the wall of the cavern seawards, is now a rocky islet, soon probably to be removed altogether.

The picturesque effects seen in the neighbourhood of such caverns are numerous and very fine. Detached rocks, pierced by natural arches—rocks connected with each other by natural flying-bridges—pinnacles and pyramids of naked rock, looking like huge artificial monoliths—all these are common. Not unfrequently, where circumstances admit, the rocks are clothed above with terrestrial green; below with brown and black marine incrustations of sea-weed, and in the middle they are grey with

lichens;—the whole mass standing forth from a bold coast, and rising out of deep water, which becomes white with foam as it heaves and breaks upon the obstacles that lie in its way.

When caves are shallow, and mere semi-vaulted recesses, the dark shadows they present are always simple, but often effective, contrasting with the more broadly-lighted sides of the cliff. When they enter further into the cliff, the view from the mouth of the cavern, looking outwards, is very grand. When they bend, and the light of day is partly lost, there is a strange pleasure in feeling one's way to the end, enjoying the fresh sea smell from the waters, but lately retired, and hearing the distant boom of the waves, whose sound is reflected from the hollow vault beyond. Often the artist is able to obtain peculiar and highly-picturesque effects from the vicinity of isolated peaks of rock near the mouths of such caverns, and not unfrequently there is a certain amount of difficulty experienced in the entry and approach, but this only enhances the pleasure of exploring, and insures quiet and undisturbed pos session.

Rarely, but still occasionally, it happens that these granite caverns are very extensive, and consist of many chambers opening one into another, and difficult of access. Crevices very narrow, but extending vertically to great height, connect openings of some magnitude. Such caverns can only be visited with artificial light, and involve some climbing and scrambling.

The contents of caverns in granite are generally confined to living limpets, sea-anemones and sea-weed sticking to the rocks, and pebbles and sand covering the floor. Many of them are remarkably rich in marine animals, but of all that have been explored none can approach the Sark caverns called the Gouliots. These very remarkable vaulted recesses are situated on the side of Sark next to Guernsey. They are the modern representatives of a succession of somewhat similar caves, the final laying open and destruction of which has caused the separation, first of the island of Brechou, and more recently of the intermediate Gouliot rock from the island of Sark. There is a wide space of cavern-floor left dry in these recesses at extreme low tides, but the caves may be visited partially, and with difficulty, at ordinary low water. The space occupied by these openings is separated into compartments by bold and grotesque arches, each compartment being the habitation of some marvellous group of marine animals. Here, owing to a combination of circumstances, there may be seen animals living and flourishing, and exposed to view, which, under ordinary conditions, require several fathoms of sea-water over them. It is a natural marine aquarium on the grandest scale, compared with which all other collections of marine animals are mere toys.

Slate caverns and sandstone caverns are different from those in granite, but the difference chiefly arises from the characteristic way in which the rock weathers. Slates present sharp lines, jagged edges, and square forms, which are retained in the caverns formed within them by the sea. In slate as in granite, the wearing away is chiefly from soft veins, and, owing to the material, it is not often that the extent is great, or the cavern tortuous or complicated.

Sandstone is rarely so hard and compact as to form a good material for caverns, and in its pure state it resists the action of water so completely that no effects are produced but those strictly mechanical. It also rarely contains systematic veins of softer material, so that although a sandstone coast-line is often extremely wild, bold, and jagged, it does not often present fine caverns. There are, however, grand exceptions, as on the south coast of Ireland, and elsewhere. In these cases arched rocks are not unfrequent, the sea undermining the stone chiefly in the planes of bedding, and entering far into the recesses of the rock before the roof falls in, and the cavern becomes a cleft. Sandstone caves may be covered with limpets and barnacles, but are not often rich in the more beautiful varieties of animal life and sea-weed.

Some wonderfully picturesque and grand caves are found connected with modern lava, and also with those ancient lava currents called basalt. The great basaltic district of the Giant's Causeway in Ireland, and the coast of the opposite islands of Scotland, are penetrated by caverns, which have often been described. Fingal's Cave is one of the best known in the British islands. Similar caves or grottos on a smaller scale are known on the banks of the Rhine, not far from Bonn; and others, again, in Italy and the various volcanic districts of Europe. The sea has had but little to do with these: they are dependent partly on the mode in which the columnar masses were originally formed, and partly on the kind of decomposition to which they are subjected.

As a wonderful contrast to these dark fire-developed recesses, these gloomy and majestic halls of Pluto, we may just allude to the brilliantly-lighted ice caverns, frequently formed in glaciers, though not often visitable by man. Nothing can be conceived more beautiful than the colour transmitted through ice, and nowhere can this be seen in perfection but in one of these caverns. The river of cold water that has formed the cavern rushes along at one's feet—the only disturbance to the dead stillness that otherwise prevails. Here is no life, no mark of life to be traced; but there is occasionally a floor of broken fragments of rock, torn away by the action of the cold that has originated the glacier in the thin air of the mountain-top.

But there is another great class of caverns very different from any of these. Limestone, like granite, is a brittle rock. It is, however, softer than granite, and is chemically acted on by water, both more rapidly and more completely. Thus, not only by the sea-side and within the action of the tidal wave, but in every place where there is a continuous mass of limestone compact enough to hold together, there are numerous crevices in the rock arising originally from fracture or contraction, and increased during elevation, but finally enlarged and converted into caverns by water.

In England such caverns occur in the compact limestones of the coast of South Wales, in many parts of North and South Devon, in Derbyshire, and in Yorkshire. In France and Belgium many others might be cited; in Central Germany there is a well-known and remarkable district honeycombed to a marvellous extent by them, while in Carniola the caverns of Adelsberg, in Greece a multitude of grottos sacred in classic story, and in America the Mammoth caverns of Kentucky, may be mentioned rather as a few examples selected at random from a countless host, than as giving any outline even of the chief localities of such phenomena. So frequent, indeed, are caverns in some kinds of limestone, that their absence, rather than their presence, is remarkable. But, on the other hand, there are some limestones that seldom contain them. Such are the Portland stone and some of the other oolites of the British islands, although corresponding rocks in other countries abound with them. Such, also, is chalk, which is too soft to admit of large halls and intricate passages, although noble vaults receding from the sea are not unknown.

Limestone caverns, commencing from or terminating in sea-side cliffs, close to the ordinary sea level, are not on the whole the most common. In this respect, therefore, they vary essentially from those in granite, and the picturesque effects obtained from them are also very different. Much more frequently they open out on cliffs or escarped faces of rock, far away from the sea; often, indeed, in river banks, but even then at levels far above the present water-line. Their openings, again, are not always large in proportion to the size of the cavern, nor have the entrances of important caverns of this kind any relation to the magnitude and extent of what is within. In all these respects they have their own marked peculiarities, and these depend partly on original formation, and partly on subsequent and long-continued wearing by running water.

Water-action, in the case of these great open spaces within limestone rock, is a force that requires explanation; for, although the result is clear enough, the exact course of proceeding is less manifest.

A mass—originally, perhaps, a pulpy mass of lime-sand, and clayey mud—is formed under water, and afterwards covered with other deposits. Exposed in this way to the influence of certain forces within the earth, it parts with much of its water, and the particles become compacted and often half crystalline. It retains, however, its character of a number of parallel beds and strata lying one above another. When such a mass, well hardened, comes to the earth's surface, and above the water-level, it is inevitably cracked and broken, some of the cracks being wide and open, and others narrow and scarcely perceptible. Once at the surface, all these crevices become water-channels, and some hill-side at a distance bleeds with innumerable little streamlets, the result of rain falling on the earth, and penetrating below the vegetation and the soil into these crevices, and so through the mass of the rock. But water thus entering limestone contains carbonic acid, having passed through the atmosphere after distillation in Nature's great alembic in the clouds, and water under such circumstances freely takes up a certain portion of calcareous matter. Every drop that falls, then, removes its particles, and the narrow fissure, through which at first the trickling water could barely find its way, is soon enlarged, and becomes a watercourse. At frequent intervals, the water reaches a bed of soft slimy mud, often found between two regular limestone strata, and its progress is then for the time interfered with. It now acts mechanically as well as chemically, and scoops out a space that, under favourable conditions, becomes itself a cavern. Forced to find its way occasionally between hard material, not favourably circumstanced for mechanical action, and then suddenly reaching softer parts of the rock, a succession of chambers is formed, which communicate, indeed, with each other, but only by very narrow crevices. Thus it arises that limestone caverns are almost always both well ventilated and wet, and generally difficult of access.

But other results are obtained from this origin. Water drips constantly through caverns once formed; it often carries along with it a certain amount of fine mud, and, as it goes on, becomes charged with as much carbonate of lime in solution as it is able to hold. Whenever the water passes over a level surface, some of the mud is deposited, and whenever the draught of air that passes through the whole series of chambers is dry enough to admit of it, part of the dropping, or dropped water in the cavities evaporates, leaving behind a film of limestone previously held in solution. In this respect, limestone caverns are entirely different from others, for the walls and floor, instead of being only mechanically worn by the rubbing of the water, are first eaten away by its solvent power, and then one part

becomes coated with a deposit removed from another part. In the course of time it will happen, under circumstances favourable for their formation, that the whole of a large district of limestone rock becomes so completely intersected by passages and chambers, and these are so affected by the removal of the surface in some places by chemical action, the wearing in other places by mechanical action, and the renovation everywhere by the deposit of successive films of limestone, as to give an appearance of artificial construction of the most complicated kind.

The deposit of successive films of limestone is generally very systematic. It produces three distinct appearances, which we may describe as stalactites, stalagmitic masses, and stalagmitic beds or strata.

Stalactites are the drooping pendants and curtains that depend from the roofs of limestone caverns. Wonderfully beautiful and picturesque are they, when seen, undimmed by smoke and dirt, in caverns that have not yet become celebrated, or in parts of large caverns rarely visited. Marvellous forms, the precise cause of which it seems almost impossible to trace, excite the imagination and suggest resemblances to all kinds of familiar and unfamiliar objects. The simplest of all are the grouped cylinders and cones of transparent cream-coloured stone, thousands of which, sometimes detached and sometimes touching each other, mark where there have been crevices through which water has oozed. When a number of drops have fallen from an extended line, a curtain is formed, with occasional fringes of the same stone. Where there have been drops long falling from a point where the drip is continuous, the pendant is on a grand scale, it grows downwards rapidly, it assumes large proportions, and becomes part of a columnar mass. Meanwhile, the whole of the water has not been got rid of at the roof, but a part has fallen to the floor and evaporated there. A base has been formed below, while the capital of the column was being traced out above. As the slender shell of stone, at first not thicker than the film that gives colour to a soap-bubble, assumes by degrees larger proportions, many drops combining in one spot, and all together tending to produce an inverted cone suspended from the roof, so in the same way does the work go on below—enlarging and spreading out, and, at the same time, rising in a conical form, until at last the two portions meet, point to point, and the column becomes complete. Sheets or curtains of stone, gradually thickening, but remaining translucent, are occasionally formed by a number of columns touching each other. These sometimes serve as walls, separating into compartments the chambers in which they are formed, and not unfrequently we meet with fantastic masses

of stalactite, more or less resembling tables, altars, organs, and other objects, named according to the taste of guides, rather than from any real or traceable resemblance.

In such limestone caverns, the smallest chambers, and often very minute subdivisions of them, are characterized by these curious accumulations quite as much as the great halls. Commencing with the lifting up of the limestone mass in its hardened state, the cracking of the surface, and the first infiltration of rain-water, the construction of ordinary stalactites and stalagmites in caverns has gone on unchecked, being guided only by the accidental course of the fissures and crevices. But there is another kind of deposit within these limestone vaults which is also interesting, and on which much depends. It is the flat floor that is commonly noticeable, especially in the chambers near the outlet, and that is independent, to some extent, of the stalagmitic base of columns. This floor is composed partly of an impalpable mud containing iron ochre, and has been derived from foreign material carried in by the water from above, or drifted in from some side entrance. From time to time, a coating of stalagmite, nearly horizontal, has formed on the surface of the mud, separating the floors of different periods of the cavern's history, and enabling us to judge of the comparative date of any foreign objects found buried. Many such coats succeed each other at intervals, and fragments of old stalactite and stalagmite are often confusedly mixed up with the mud of the floor, and re-cemented.

This brings us to the second part of the history of caverns, which we must reserve for another chapter. It will there be shown that, connected with the mechanical facts we have been describing, there is associated a group of natural-history facts of the most singular kind, pointing to conclusions with reference to organic life, and even to the history of the human race, not surpassed in interest and importance by any department of geological investigation.

THE LOWEST FORMS OF LIFE.

PART II.

THE PROTOZOA OR LOWEST ANIMALS.—"VORTICELLA," OR THE "BELL-FLOWER ANIMALCULE."—CONCLUSION.

BY THE EDITOR.

THE reader will recollect that we were last occupied in investigating the nature of that simple fabric, known as a vegetable cell, and that beautiful plant-form, called *Volvox globator* ("the rolling globe"), which is a group or assemblage of such cells endowed with the power of locomotion.

If he feels disposed once more to join our little family circle, he will have an opportunity of considering with us some objects of still greater beauty and interest. As we sat at the tea-table a few evenings subsequent to the one to which we referred in our last number, our conversation turned upon the subject of our former inquiries, and I was asked in what the difference between a plant cell and an animal cell consisted.

My reply was as follows:—

"For the most part we find the animal cell enclosed, in the same manner as the vegetable cell, in a capsule, or 'integument,' as it is called; the latter word expressing the same meaning as a 'skin' in the higher animals. Both in its constituent compounds and in its anatomy, however, the animal differs from the plant cell: the latter I have already described; its 'cell-wall' is a distinct membrane, consisting of a substance called 'cellulose,' which resembles starch in its nature; and within that, we find the *cell contents* ('endochrome'), believed to be surrounded by an invisible membrane of an albuminous character; the cell-contents consist, as you know, of those green granules that are formed within the capsule, and which float about in the more fluid sap. Now the *animal* cell has no such external coat of cellulose, as we find in plants, but only the inner albuminous envelope, which in the animal cell is the outer protecting coat, or skin, and consequently we find it to be much firmer and thicker than in the plant; in fact, you might say that in the animal cell, the inner membrane being of a tougher consistency than in the plant, the outer one is usually dispensed with. In its place, however, we often find what is called by microscopists, a 'carapace'—a comparatively hard shell, or armour, of which the true nature is not yet clearly defined.

"Then again, in the animal cell the internal granules are not

formed as in the plant cell, but a regular consumption and digestion of food takes place, even in such as do not exceed one-thousandth part of an inch in diameter. . . . . Ah! you may smile; but I mean to feed some of them this evening, just as they feed the higher animals at the Zoological Gardens; and when you have seen them at meals, perhaps your scepticism will be at an end."

At this last observation of mine, my little auditory laughed outright, for they regarded the statement that an invisible globule, "not exceeding one-thousandth part of an inch in diameter," could be fed in the same manner as a quadruped, as a barefaced attempt to practise upon their credulity; and, laughing heartily, we all adjourned to the study to witness this wonderful phenomenon.

"This is a very graceful cluster of flowers," my pupil remarked, as she leaned over the microscope, after I had prepared a slide for her inspection; "but you said that you were going to exhibit to us some forms of animals."

"Why, good heavens! these plants are all instinct with life! How they sway from side to side, coiling and uncoiling their stems!—and see, that central one that towers above the rest has disappeared, whilst I speak. No! here it is again, slowly uncoiling its footstalk.

"How beautiful! There to the right are two, drooping gracefully, with all the elegance of Canterbury-bells, and wooing one another like lovers; and yonder to the left we have matrimony typified—two bells upon one stalk.

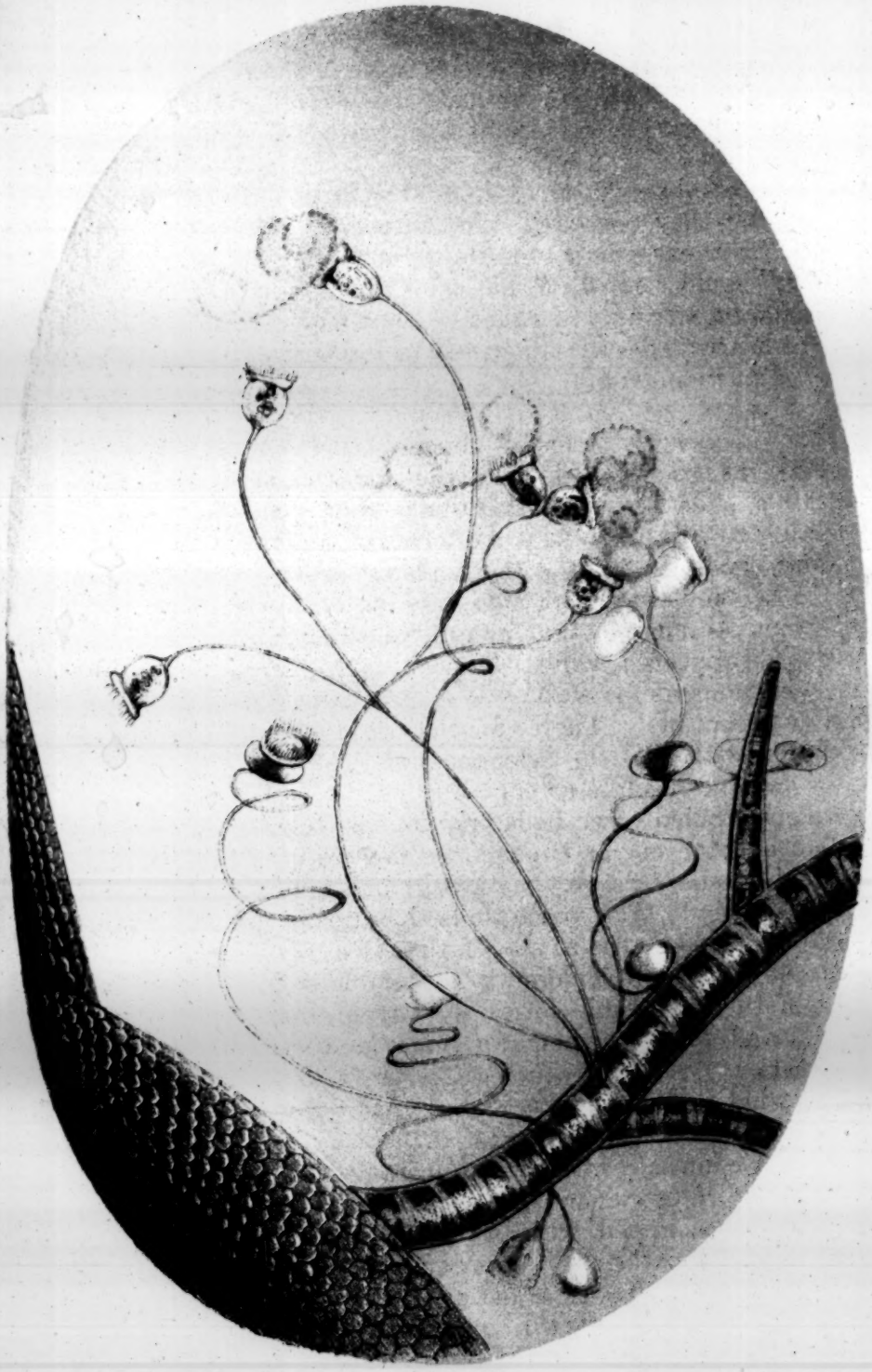
"And look! even the cups of the flowers have the power to change their shape; now they are globular, now vase-shaped!

"How lovely! *This* scene, indeed, eclipses your Volvox and all your plants—that is to say, if these be not plants also, for your disclosures have rendered it impossible to judge of the true nature of these invisible forms by any ordinary standard. I could sit and gaze on them for hours and watch their varied movements.

"But what are those blue flakes that revolve in a current around the cups of the flowers?

"Well, I confess you are unfolding to us the invisible works of nature, with ever-increasing interest and attraction. Let them all approach and witness this wonderful sight, and then we will again be patient listeners and learners."

"You will *have* to be a patient listener this evening," I remarked; "but as you will only be doing penance for the ridicule with which you just now treated the information that I gave you, I shall not deem it necessary to apologize for testing your powers of endurance.



T. del. ad nat.

J.H. Ford Lith. W.West imp.

The Bell-Flower Animalcule
Vorticella nebulifera

"I intend, this evening, to answer fully some questions that you put to me the last time we examined these forms together; but first I will satisfy your curiosity, by saying that the 'flowers,' which you have just been inspecting are living creatures called *Vorticellæ*, from the curious little vortex or whirlpool that they create in the water in order to attract their nourishment, consisting in this instance of the flakes or particles of indigo, with which I have been feeding them. Now, where is your unbelief?"

"Well, I confess that my incredulity got the better of my judgment; so pray pardon me, and proceed."

"In investigating these mysterious living atoms, I must, in the first place, say a few words to you concerning those two curious forms of life, the *lowest* of any yet discovered, *Amœba* ('the changing animalcule'), and *Actinophrys Sol* ('the rayed or radiating Sun'), both of which we inspected on a recent occasion. The first of these, Amœba, puts out temporary members ('pseudopodia,' or false feet, as they are called), and by this means moves about in search of food, or rather, I should say, until it accidentally comes into contact with something that will serve for its nutriment. The mode in which these feet are *improvised* is very curious. Amœba itself consists, practically speaking, of a mass of cell-contents (called by naturalists 'sarcode'), without a cell-wall, but there is probably at its circumference a thin elastic membrane, which becomes extended in the direction in which the animalcule means to move. At first the false foot is transparent, but presently the granules that float about in its body set up a current in the direction of the false member, and, flowing into it, cause it to resemble the rest of the body. (Plate vii., fig. 1.)

"When the Amœba comes into contact with any substance suitable for its nourishment, it enfolds it with these false members, and drawing it into its body through an extemporised aperture, it sucks out the nutritious constituents by the digestive process, and ejects the indigestible particles by another opening in the body ruptured for the occasion. And, wonderful to relate, it performs this operation, so indispensable to the maintenance of its lowly existence, without any organs of digestion whatever. The only approach to organization, visible within its body, is a little hollow sphere, that appears to serve as a receptacle for the fluid product of the digestive process—the blood, as it may be popularly called. This sphere contracts and totally disappears from time to time (hence it is called the 'contractile vesicle,') and then gradually dilates again; and, as microscopists believe it to be a kind of circulating apparatus, analogous to the heart, they have called

this rhythmical contraction and dilatation, the 'systole' and 'diastole,' terms employed in connection with the movements of the last-named organ in the higher animals.

"Thus you will see that Amœba which is at present regarded as the lowest type of animals, is in fact a mass of cell-contents, or 'sarcode,' without a definite cell-wall, possessing the power of locomotion, and the capability of nourishing itself. How it reproduces itself; and whether it really is a perfectly formed animalcule, or only the early stage of one, is not definitely ascertained.

"The other living type, Actinophrys (pl. viii., fig. 2), differs from Amœba chiefly in its members of locomotion being constant, and in the structure of the body being reticulated after the manner of a honeycomb, and not gelatinous; indeed, it resembles the section of a minute twig of the pine.

"Its locomotive members (pseudopodia) are believed to have the power to paralyze its prey, which you will be surprised to hear often consists of highly organized animalcules.* These it engulfs in the same manner as Amœba, digesting the nutritive portion, and ejecting what is indigestible.

"Let me just relate one more circumstance concerning Actinophrys, and then we must pass on to the bell-flower animalcule.

"When two of these forms come into contact with one another it is not at all uncommon for them to coalesce so completely as to form one perfect animalcule; and the new creature possesses precisely the same properties as the two of which it is composed.

"I mention this circumstance, in order to show you how remarkably simple must be the structure of the 'lowest forms of life,' when two of them can amalgamate, and yet retain their vital properties unimpaired.

"In concluding my remarks concerning them, I would observe that they have been placed by systematic zoologists in a group of animalcules, called 'Rhizopoda,' or 'root-footed,' from the peculiar shape of their members of locomotion.†

* Amœba, I believe, feeds on the simplest kinds of plants.

(Pl. viii., fig. 2, represents *Actinophrys Sol*, as I have myself seen it, seizing and digesting a Stentor, or trumpet animalcule.) In Actinophrys the contractile vesicle is clearly visible, and after a meal its contractions and dilatations are very regular and perceptible. (Fig. 2*a*.)

† Mr. J. R. Greene (whose excellent little work, "A Manual of the Sub-Kingdom Protozoa," is strongly recommended to the *student* of this branch of natural history) aptly describes Amœba; and the extraordinary phenomena which accompany the life of this lowliest of living forms warrant me in making an extract—even at the risk of a little repetition:—

"When first placed under the microscope, the Amœba presents the appearance of a globular mass of a semi-transparent jelly, destitute of any apparent organization. This seemingly helpless being soon, however, commences to show signs of life, by pushing out in various directions portions of the jelly-like substance of which it is composed. By expanding one of these prolongations,

"The bell-flower animalcule, or Vorticella, as it is called by microscopists, belongs to a group of animalcules, termed 'Infusoria,' in consequence of their being sometimes found in infusions of decaying animal and vegetable substances.

"To the investigation of this group of animals, Ehrenberg, an eminent Prussian microscopist, has devoted a considerable portion of his lifetime, and although his observations upon their *structure* have been shown to be incorrect, yet it is to him that we owe our knowledge of the existence of vast numbers of these forms of life. I shall not perplex you by recording the errors into which Ehrenberg has fallen, but will now endeavour to communicate to you, as popularly as possible, the authentic details that I have been able to collect by reading and observation, concerning the natural history of the bell-flower animalcule.

"Whilst I am describing its movements and habits, however, it would be as well for you to have one of the living animalcules under your eye, and I will therefore try to find one for your inspection.*

"Vorticella consists, as you perceive, of two parts, of which the one may be familiarly called the cup, and the other the foot-stalk, or as they are termed by naturalists the 'calyx' and 'pedicle,' and certainly of all living forms none so closely resembles a flower in shape as does this one.

"The calyx is formed after the model of a cup, or vase, but it has a contractile power (as has also the pedicle), and frequently it assumes a globular form.

"The pedicle is a long contractile appendage to the cup, and it derives its power of coiling and uncoiling itself from the delicate filament, which you may trace through its whole length." (Pl. viii., fig. 3*a*.)

and then drawing after it, or rather into it, the remainder of its body, Amœba slowly advances in a somewhat irregular manner. . . . Should the Amœba, in its progress through the water, come in contact with any foreign substance of small size, the latter is tenaciously grasped by the pseudopodia which coalesce around it, and thus the morsel soon becomes inclosed in the interior of the body.

"There is no true oral orifice (mouth), and the mode in which deglutition is performed by the Amœba may not inaptly be illustrated by forcing a stone into a lump of clay, or similar plastic material. The power of selection possessed by the Amœba would appear to be but slight, either as to the quantity or quality of its food. Inorganic particles, such as sand, are frequently ingested along with its more proper aliment. Sometimes the body of the Amœba appears as a mere transparent film, investing the substance swallowed; and it occasionally happens that it becomes impaled on the sharp point of some projecting object. The indigestible remains of the food are finally pushed out through some part of the gelatinous body."—(pp. 3-5.)

* The reader would do well to refer to plate vii., whilst following this description, unless he can obtain a living specimen. They are found in infusions of hay, also attached to duckweed in ponds, and in other localities.

"A kind of muscle, I suppose?"

"No, not exactly a muscle; it is a portion of the substance of the animalcule, endowed with this contractile property: that is the best definition that we can at present give of its nature. If you watch it *un*coiling (for it coils up so rapidly that the eye cannot follow the movement), you will distinctly see the internal filament elongate, and assume a wavy appearance as it is extended, until at length it becomes almost straight from end to end."

"But, stay a moment," observed my pupil; "how does it happen that when the pedicle, as you call it, becomes extended, the cup, which, during the coiling process, had assumed the globular form, also expands, and there seems to be a kind of agitation all round the rim, when the flower is fully blown, if you will allow me to employ the expression? What is that vibration?"

"It arises from the action of an appliance that the animalcule possesses, to enable it to obtain a supply of nourishment,—a circlet or wreath of 'cilia,' little hair-like appendages, similar to those that I showed you upon the cells of Volvox."

"Why, then, this bell-animalcule may be a vegetable, after all, if it is furnished with such organs."

"On the same principle, then, you and I may be vegetables; also the oysters that we consume. Have you forgotten what I told you concerning them, when I showed them to you upon Volvox: that they are found in ourselves, and are numerous in the gills of the oyster? In Vorticella, they supply the place of pseudopodia, the false feet of Amœba, and the Sun-animalcule; for, by their rapid vibrations, they cause a current to flow constantly in the direction of the mouth, and this brings with it a supply of nourishment for the animalcule. This I will demonstrate to you by an interesting experiment."

So saying, I removed the slide from the stage of the microscope, and, taking a clean one from my cabinet, transferred to it, from a small bottle, a fresh drop of water containing some more Vorticellæ.

"These animalculæ have not yet been fed with indigo," I observed, after having satisfied myself that the drop contained some of the living forms in question; and taking from a box of colours near at hand, a small cake of indigo, I rubbed it in a little water upon another slide, and then transferred a drop of the solution to the slide with water containing the Vorticellæ, and replaced it on the stage of the instrument, having previously covered it with a small piece of thin glass to prevent the evaporation of the fluid. This operation completed, I invited my friends to draw near, and inspect my little charges at their meals.

"So, these little flocculent particles that float about in the water are portions of the indigo in solution, are they?"

"Yes; they are the magnified flakes of that substance held suspended in the water; and now if you look at the rim of the calyx of one of the Vorticellæ, you will find that the current brings a continuous supply of the indigo into the mouth or oral aperture, as it is termed, of the Vorticellæ."

"So it does," said my young pupil, after watching the operation for a time; "and inside of the cup little blue balls or globules are formed,—portions of the food undergoing digestion, I suppose?"

"See how acute your faculties are becoming by observation," I exclaimed. "The globules are, indeed, portions of the food undergoing digestion, and I will describe this process, so far as we are acquainted with it, in Vorticella and other infusorial animalculæ.

"The body or calyx of the animalcule is composed of a little mass of substance similar to that of Amœba, but Vorticella is inclosed in an elastic contractile skin or integument. Some observers believe this 'skin' to be made up of two distinct membranes, the inner one being contractile, and *extending into the pedicle or foot-stalk, so as to constitute that remarkable contractile filament, which imparts the power of coiling and uncoiling to the appendage in question.* (Plate viii., fig. 3 *b*.) The soft semi-fluid substance of the calyx contains a rudimentary, digestive, and circulating apparatus, the food being admitted through an aperture situated within the rim of the cup. . . . . I have been trying to call to memory some familiar object that will afford you an idea of the calyx or cup of Vorticella, but the only one to which I can compare it is a common breakfast cup into which a circular piece of cardboard has been inserted, so as to leave only the rim of the cup visible. Suppose you were to cut a piece of paper or cardboard to the shape of the cup at its widest part, and make a hole in the cardboard a little to one side from the centre, you would imitate to some extent the 'disk,' as it is called, which closes the wide aperture of the calyx of Vorticella. The circlet of cilia is disposed spirally upon the disk within the lip or rim, and is continued a little way into the mouth or oral aperture, which is represented in my simile by the hole in the cardboard that closes the aperture of the cup (fig. 3).

"Now, watch the current of indigo carefully, and you will perceive that it forms a kind of *vortex*, or whirlpool (hence the name *Vorticella*), the object of which is, that any particles of matter unsuitable for nutriment may be rejected; and, according to the observations of some microscopists, there is

an appliance within the entrance to the rudimentary stomach that aids in the selection of suitable nourishment."

"I see the little whirlpool very distinctly, for here the course of the current is plainly indicated by the innumerable particles of blue colouring matter mixed with the water (plate vii.); but, curiously enough, although I fancy I can see a little ball of food (of indigo, I should say,) forming near the mouth, yet I do not see the particles enter at the aperture." (Plate viii., fig. 3 *c*.)

"No; because they chase one another with such rapidity that it requires a practised eye to follow them in their course. You were correct in saying that you see a ball of food forming near the mouth. The food accumulates at the bottom of a little tubular or funnel-shaped excavation in the external envelope of the body (communicating with the water through the oral aperture), and when the ball has attained a certain size, it is forced, either by its own weight or by the current from without, into the interior substance of the calyx, whilst the formation of another little pellet at once commences. If you were to watch these pellets, you would find that, after they have escaped into the cup, they continue to rotate (very slowly in Vorticella, but more rapidly in some others of the Infusoria,*) until the whole of the nutritive portion is extracted, and then the residue is ejected at the rim, and carried away by the receding current. Some microscopists believe that it is expelled by a second special aperture. This observation may be correct, but I will not be responsible for its accuracy. So much for the digestion of the food. Now a word regarding the means whereby the liquid product of digestion is circulated through the body so as to minister to its growth.

"This fluid, which is analogous to the blood of the higher animals, is collected in a contractile cavity resembling those which we found in *Amœba* and *Actinophrys Sol*, but in the Infusoria it is more perfectly organized. You know in what manner our heart operates, driving the blood by its contractions through arteries to all parts of the body, and receiving it back through the veins. Well, in some of the Infusoria the contractile vesicle, which is, in fact, the first trace of a heart in the animal kingdom,† mimics this operation of the more

* Plate viii., fig. 4, represents the digestive process in another infusorial animalcule, "*Glaucoma scintillans*," in which it may more readily be followed :—

a Oral aperture, or mouth.
b Pellet forming at the bottom of the rudimentary throat.
c Pellets in the body.
d Digested remains of food escaping from the body.

† According to some naturalists, it is the rudiment of what is termed the "vascular water system" in the worms.

perfect organ; so much so, that the contractions and dilatations in both cases are known to physiologists by the same scientific designations, the 'systole' and the 'diastole.' In another of the Infusoria I have seen this action very perfectly displayed. The animalcule is called *Glaucoma scintillans* (the 'scintillating or sparkling Glaucoma'); and here, when the vesicle contracts, five secondary ones make their appearance around it, and into these spaces the fluid penetrates. As the central vesicle dilates again, its satellites contract and disappear." (Pl. viii., fig. *e*.)

"And are there any veins or arteries in the Infusoria?"

"I have not observed anything analogous to these vessels in the animalcule just named; but in another (*Paramecium caudatum*, pl. viii., fig. 5), I have noticed a number of little channels radiating from the contractile space.* These seem to represent the arteries; and when the vesicle contracts, they expand and become visible. Near the vesicle they are bulb-shaped, and they become smaller as they recede from the 'heart.' Just as in the case of the smaller vesicles that surround the central one in Glaucoma, these arterial vessels disappear as the contractile vesicle expands and receives back its contents. Is it not wonderful how the designs and operations of the Infinitely Great may be traced even in His infinitely small creations!

"And now, having explained to you the digestive and circulating process in Vorticella, and some of the other infusorial animalculæ, I must conclude its history by describing its mode, or rather, I should say, its modes, of reproduction. It is reproduced by at least three, and, according to some physiologists, by four, different methods. The first is by subdivision: that is the most simple and the most easily watched; indeed here is one undergoing subdivision: you had better all inspect it before I explain the process (pl. vii.). You will notice that there are two calyxes or cups upon one stalk."

"Yes; and one of the cups has a double circlet of cilia, one at the rim and another close to the stalk. What is the use of the second circlet?"

"I will tell you presently.

"When a Vorticella is about to subdivide, it becomes indented longitudinally; that is, from the stalk to the rim. This indentation becomes deeper and deeper until the calyx is separated into two parts, as you see, both remaining on the same stalk (pl. vii.). Presently the second circlet of cilia is formed on one of the cups (I say presently, for the whole process of subdivision rarely occupies above an hour), and these new cilia, by their rapid vibrations, twist the cup off the stalk.

* P. caudatum has two such spaces.

"The free Vorticella, that is, the calyx which has been detached, swims about very rapidly by means of its two circlets of cilia; but at length one of these disappears, namely, the circlet that was originally situated at the rim. This end of the calyx then attaches itself to some floating object, and puts forth a pedicle or footstalk, the opposite end becoming the one at which food is received, for a new 'mouth' is formed within the wreath of cilia that aided to twist it off the old footstalk. So you see the parts of the calyx change their functions, and very soon the process of subdivision commences afresh.

"Sometimes, however, the fission is not confined to the calyx, but extends into the pedicle; and under these circumstances, it is incomplete, and the two animalcules, or rather the two cups, remain permanently attached. When this abnormal process is often repeated, the whole group assumes an arborescent appearance, and such a group has obtained the name of Carchesium, or the Tree-Vorticella (pl. viii., fig. 6).* The group of living flowers, therefore (in some cases attached by their several footstalks to one central stem), is the result of *one* of the reproductive processes in Vorticella, namely, that of fission or subdivision.

"The next is called 'gemmation' or 'budding;' but it is not of such frequent occurrence. . . . . Let me endeavour to illustrate this budding process by a simile. Can you imagine a Canterbury-bell producing another cup through the growth of a bud, not upon the footstalk, but close to it, on the flower itself? If so, you will understand how the young Vorticella-bud grows, as it were, from the calyx of the parent (pl. viii., fig. 3). It is nourished by a connection with the latter until old enough to lead an independent existence, and then a circlet of cilia is developed at the part attached to the parent, by which means, as in the former case, it frees itself, swims about with the aid of its cilia, develops a pedicle, and becomes sedentary, or 'sessile,' as it is scientifically called."

"Just as in our case," said my pupil, laughing; "first it leaves its parents to sow its wild oats, and then settles down to a quiet life."

"Precisely so: and now for the last process of multiplication, which is rather more difficult to describe in popular language than the others, but I will do my best to explain it.

"Within the cup of the Vorticella there is a little sausage-shaped object called the 'nucleus.' (Pl. viii., fig. *d*.) At a certain stage of its humble existence the animalcule shrinks up into a ball, and a gelatinous or glutinous substance exudes from its body, entirely encasing it. In this state it is called

* From Dujardin's "Zoophytes Infusoires."

Plate VIII.

Fig: 1.

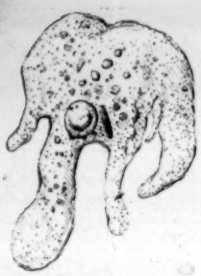


Fig: 2.

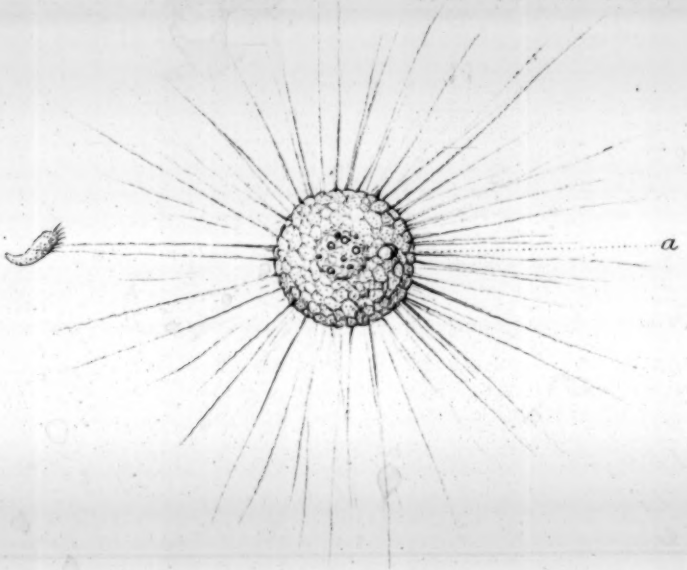


Fig: 3.

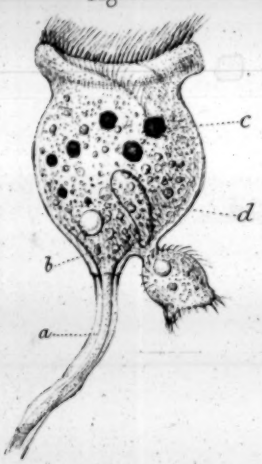


Fig: 6.

Fig: 4.

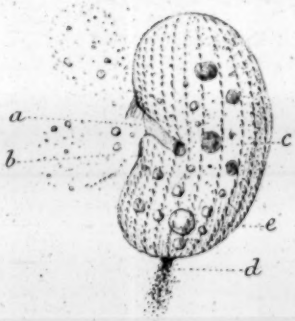
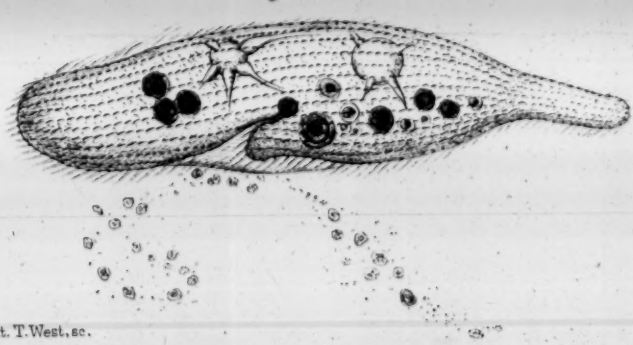


Fig: 5.



J. Samuelson, delt. ad nat. T. West, sc.

W. West, imp.

'encased' or '*encysted*,' that is, enclosed in a '*cyst*' (from a Greek word, signifying a bag). The cilia disappear, the pedicle soon drops off, the contents of the calyx lose their granular appearance, and the only signs of organization that remain are the 'contractile vesicle' and the sausage-shaped 'nucleus.'

"The last-named begins to subdivide in a similar manner to the contents of the cell in Volvox, and in the course of time the whole 'cyst' or capsule is filled with a swarm of little oval animalcules.

"At length, the outer integument can no longer resist the pressure of the young brood, and it bursts. The freed Vorticellæ make their escape and swim off in every direction, being furnished at their birth with a little wreath of long cilia. Just as in the two preceding cases, they sport about for a time in the watery element, and when they have attained a certain growth, put forth a footstalk, and 'settle down to a quiet life,' as you were pleased to designate their 'sessile' stage.

"I must now draw your attention to another parallel between these lowest forms of animal existence, and the *protophyta*, or lowest plants, namely, the 'settling down' and becoming encysted; for, if you recollect, precisely the same process preceded the reproductive act in the little ciliated plant forms, and not that alone, but the budding process, the 'gemmation' of Vorticella strongly resembles the same operation in plants, with this difference, not to be overlooked, namely, that the Vorticella bud derives its nutriment from the fluids in the parent, elaborated on the digestion of organized substances, whilst in the case of plants the 'pabulum' or food is derived from the inorganic constituents of the surrounding elements.

"More I cannot tell you about Vorticella, for it would occupy too much time to describe the various shapes under which it presents itself. Sometimes it resembles a shrub, of which the central stem only is rigid, and the branches with their calyxes contractile: it is then called 'Epystilis,' the 'pillar animalcule;' at others it is enclosed in a beautiful cup-shaped sheath; indeed, its varieties or species are manifold, but all are alike interesting and beautiful.

"Before, however, we bid adieu to these humblest forms of life, let me just remark that you are daily in the habit of employing, perhaps unconsciously, substances whose nature is akin either to the lowest animal or vegetable types.

"The common sponge, for example, which you use in your bath, is closely allied to Amœba; for whilst it was growing in the sea it formed the support or framework of an extended slimy skin similar to Amœba in its living properties. Sometimes the inner skeleton, instead of being flexible and horny, is silicious; that is to say, it is composed of innumerable flinty

particles, resembling radiating spikes, visible only with the aid of the microscope. Although a beautiful microscopic object, it is in that case valueless as an article of commerce.

"Some of the building materials employed by man are composed of the calcareous shells which formerly sheltered microscopical forms of a similar character; and the pyramids of Egypt are constructed of a stone that consists almost entirely of the shells of one well-known fossil species.

"Again, you have probably heard that the inhabitants of some of the poorer districts in Norway mix earth with their bread. This they call 'bergmehl,' or mountain flour; and Ehrenberg found, on examining it under the microscope, that it is composed almost solely of the exquisitely carved fossil cases or coverings of a number of very lowly forms, so lowly indeed, that it is undecided whether they belonged to the animal or vegetable kingdom. It is, however, usually supposed that they still retain sufficient organic matter to impart to them a slightly nutritive property; and they are so beautifully framed, notwithstanding their excessive littleness, that no collector regards his cabinet complete without specimens of the various types.

"And one more example you will find in a very fine polishing powder, which is employed on account of its hardness to burnish metals and stones, and in the flinty stone called 'tripoli,' from which it is obtained. This, too, consists entirely of fossil silicious shells.

"Many are the objects to which I could draw your attention, whereof you do not know the true nature, but which are constituted of these animated atoms, either recent or fossil; and naturalists have but just commenced the study of this branch of science, new substances being continually discovered in which these humblest of animated types are revealed with the aid of the microscope; indeed, it has been shown, beyond a doubt, that whole mountain ranges on land, and beds of sand in the ocean, are composed entirely of their invisible habitations."

It was late in the evening when I had concluded this brief discourse upon the lowest forms of animal existence; and, left alone in my study, I sat down, as is my wont, after inspecting the beautiful scenes of the microscopical world, to reflect upon the lessons which they convey to the thinking mind.

My thoughts wandered back to the time when all these strange phenomena, these evidences of the Creator's presence in every atom, were still concealed from the vulgar eye, and were known more imperfectly even than at present, and only to the privileged few. And then they sought to pene-

trate into the future; and I could picture to myself the time when every workman at his bench would be able to recognize in each fragment of the material that passes through his hands an evidence of the Wise Power which controls his own operations as well as those of nature.

And when I drew a comparison between the life of one of my own race and that of a Vorticella, I was surprised to find how many men there are who seem to take the animalcule for their model; whose birth, growth, nourishment, wanderings, and, finally, whose tranquil "fixed" existence all resemble that of the little bell-flower animalcule! A sense of awe crept over me when I recollected that, sooner or later, we all sink to rest as does the Vorticella, or the Volvox in its winter stage; but gloriously above all these thoughts rose the knowledge of the fact, that even these senseless, soulless beings do not *die*, but that the germ retains its existence and gives rise to fresh forms of grace and beauty.

"Fair summer's bloom and autumn's glow
In vain pale winter brave;
Nor youth, nor age, nor wisdom know
A ransom from the grave!

"But morning dawns and spring revives,
And genial hours return;
So man's immortal soul survives,
And scorns the smouldering urn!"

CONTRIBUTIONS TO THE HISTORY OF THE ROTIFERA, OR WHEEL ANIMALCULES.

BY PHILIP HENRY GOSSE, F.R.S.

II.

THE FLOSCULES

(Floscularia).

'TIS a lovely morning in the end of April. We have taken a long walk, and find ourselves in the midst of a bowery lane, with tall hedges overarching on either side—elm, and sloe, and hawthorn,—all glowing in the bright tender green, the fresh verdure of the opening spring. The road is hard and firm to the tread, for the nocturnal shower has only sufficed to lay the dust, and has been absorbed, while its myriad drops yet sparkle on the shooting grass-blades. Vegetation is marching with a giant's pace, after the dull sleep of frozen winter. The large glossy black-spotted leaves of the wake-robin are fringing the hedge-bank, and the swelling spathe is here and there seen, sending up its pointed canopy; but you must violently tear open the curtain if you would see the fair lady within, for she is not yet dressed to receive company. The beautiful heart-like leaves of the black bryony, vying with those of the arum in polish, and excelling them in shape, are rising on their slender twining stems, and rapidly creeping to the summit of the hedge. Even the very nettles look so fresh and tender that we half forget their insidious ferocity, and look with complacency on them as an essential element in the verdant scene.

But it is not *all* verdure: Flora smiles here too. Thick clusters of pale-yellow primroses sit in their crumple-leafed crowns, and scores of deeply-purpled violets are revealed by the gushes of fragrance that ascend from the tangled herbage. The white starry blossoms of the stitchwort spangle the bank, and among them the laughing blue eyes of the germander speedwell—"angels' eyes," as our country lads poetically call them—peep out by hundreds. Yonder, the tall erect spikes of the blue hyacinth are nodding, and the rose campion and ragged robin display their crimson flowers. Higher up, the sloes are white with bloom, and in the orchard over the hedge the delighted eye gazes on great masses of blushing silver.

The early butterflies are abroad. The garden whites, those

foes to our cabbages, are flitting everywhere. Yonder, we see the brilliant little copper playing, coy in its conscious beauty as a coquette in a ball-room; and here comes, sailing down the lane, the gay brimstone, paling the primroses on which it alights with its deeper hue.

Hark! from the apple-orchard is poured the mellow song of the blackbird. Soft and low, but most rich and clear, the notes are trilled. Presently he is answered by the loud rivalry of the missel-thrush, who vociferates, "You thief! you thief! you thief!" as loud as he can whistle: bad language, only redeemed by the mellifluous tones in which it is uttered. And there, overhead, in the brightening sky, is the soaring lark, pouring forth his gushes of sweet melody, which we have been hearing for the last half-hour, without adverting to it, busy as we were in indulging the eye, and only now suddenly awake, so to speak, to the full consciousness of the proximity of the cheery bird.

Here, beneath the arching fronds of the lady-fern and hart's-tongue, which, in this sheltered nook, the withering touch of frost has scarcely sullied, we catch glimpses of quiet water; a deep ditch, which has just sufficient fall to maintain a gentle flow, and to keep the water in purity. The aquatic vegetation is already greening the sides, and fast rising to the surface, destined, before long, to fill up the cavity with its grosser luxuriance, and then die away, for want of moisture, beneath the burning sun of June.

Now, this ditch is the terminus of our walk. Our sweet fresh stroll, through fields and lanes, in this early April morning, has had this identical rivulet in view as its object. So, after having drunk in the suffusing loveliness awhile, and gratified all the senses at once, sight, smell, hearing, and feeling too,—for the genial sun, just warm enough to be pleasant, and the gentle aura that fans the face, gratify that sense also,—we turn out half-a-dozen glass phials from coat-pockets, and, unfolding a twist of twine, lash one of them to the tip of our walking-stick, and commence operations. A little of the water is dipped up from the edge, and transferred to one of the spare bottles; then a second dip from near the bottom, keeping the dipping-phial inverted till the bottom is reached; then a third, from the middle of the weeds, and so on; and when we have made our collections we sit down on this felled tree, and examine.

A pocket-lens of two glasses, giving, when combined, a magnifying power of some twenty-five or thirty diameters, we bring to bear on each bottle in succession, holding it up to the light, and passing the finger up and down behind it to give a dark back-ground. What have we secured? Some trans-

parent worm-like larvæ of flies, a blood-worm or two (also fly larvæ, these); half-a-dozen pupæ of gnats alternately floating to the surface and vigorously scuttling down again; some water-fleas, minute leech-worms (*Planaria*), and young pond-snails; these chiefly in the phial of bottom sediments. Such are our captures, all capable of affording both amusement and instruction, but not the things we came for. We are out on the quest for ROTIFERA, and of these the water reveals but few. Gnat-grubs and water-fleas are particularly inimical to the elegant little denizens of the pools that we are studying, and where the former abound the latter will generally prove to be sufficiently scarce.

But *nil desperandum!* There is hope yet in the submerged vegetation; and so, stooping down by the ditch-brink, we drag up a mass of the water-crowfoot, the leaves of which, when growing beneath the surface, are cut into deep and slender finger-like filaments, while those which lie on the top are comparatively entire. A few of the lowest leaves,—the most ragged-looking, half-decayed, half covered with soft sediment,—are quickly plucked off, and pushed into one of the phials of water, and with these we go home in hope.

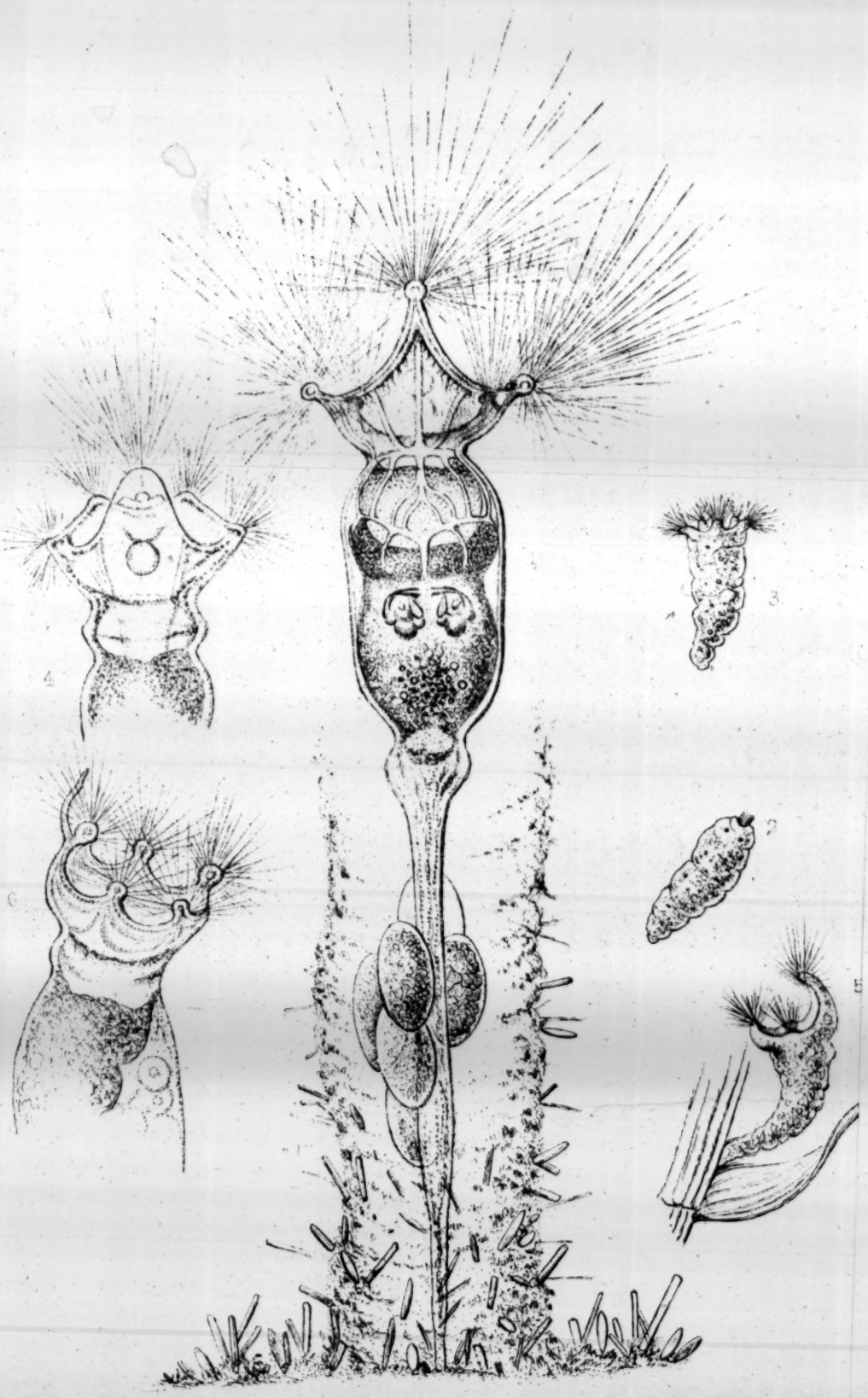
Seated before the microscope, one of these ragged filamentous leaves is cut off, and laid on the glass bottom of our live-box, a drop of water is put on it, and the glass cover pressed down. Now the filaments are examined in detail, with a low power, and presently we discover seated on them, as we had hoped, specimens of the lovely *Flosculária ornata*, which must now be described. (See plate x., fig. 1.)

With sufficient general resemblance to the Crown animalcule to warrant our uniting these two in one family, the Floscule differs from it in the following generic characters:—

GENUS FLOSCULARIA (OKEN).

Frontal lobes short, broad, knobbed, expanded; ciliary setæ very long, radiating, crowded about the knobs; jaws each of two teeth.

This genus, especially in its most common and best known species, *F. ornata*, is one of exquisite delicacy. It is far inferior in size to the *Stephanoceros*, and cannot compete with it in majesty of form, but it, perhaps, surpasses that fine species in elegance and grace. It may be compared to a long tubular flower, with a five-angled petal, somewhat like that of a convolvulus, the tube swollen, and contracted below the lip, and seated on the end of a long stalk. A glance at the figure in plate x. will, however, give a more exact idea of the graceful animal than this comparison, which yet has sufficient *vraisemblance* to have obtained for it more than one scientific



P.J. Cosse del. ad nat. F. West sc.

W. West imp.

Floscules

appellation;—Pallas having given to the species the name of *hyacinthinus*, under which name (*Vorticella hyacinthina*) it takes its place in Gmelin's edition of Linnæus's *Systema Naturæ*; and Oken making in 1815 a genus of it by its now accepted title of *Floscularia*, from *flosculus*, a little flower. The name of *ornata* was given in 1830 by Ehrenberg, who apologizes for not using Pallas's appellation, on the ground that the vagueness of the early microscopic observations make it somewhat uncertain whether their species was truly identical with this. Still, from the commonness of our little beauty, not much doubt can be entertained that it was this species which they saw.

The dimensions of the Beautiful Floscule, as measured by myself from an average specimen, are as follows:—The height of the case $\frac{1}{90}$th of an inch; height of foot $\frac{1}{100}$th; of foot and body to tip of tallest petal, $\frac{1}{60}$th; of entire animal from base of tube to tip of longest bristles, so far as they can be traced, about $\frac{1}{35}$th. Individuals, however, much exceed these dimensions: I have measured one which attained the height of $\frac{1}{80}$th of an inch to the petal-tips, which may have given $\frac{1}{25}$th as the total altitude: the case of this specimen measured $\frac{1}{40}$th of an inch.

The foot is a slender column, not perfectly straight, nor of uniform thickness; it often displays irregular bendings, sometimes amounting to abrupt knee-like angles, and has in general one or more swellings or bulgings, equally irregular. These are accidental, for they do not always occur at the same point: there is, however, one which is more constant, though not uniformly so,—a considerable angular swelling just below the merging of the foot into the body.

The body is sub-oval, sometimes very regularly, but at other times (plate ix., fig. 1), a little enlarging at the upper end. Above this, there is a constriction or neck, but not so well defined a collar as in *Stephanoceros*. From this neck the beautiful flower-like disk opens, an expanse of the most exquisitely delicate and brilliantly transparent membrane, which, as I have said, forms five blunt points,* equidistant, and

* I have never been able to obtain a specimen with more than five points. Ehrenberg, however, assigns six to it, in his specific diagnosis of the species, and in his description. He figures one, however, with five. Dujardin and Peltier in France, and Leydig in Würtzburg, allow of no more than five. On the other hand, Dr. Dobie quotes Mr. Hallett, who "finds *F. ornata* six-lobed." Mr. Slack seems to cut the knot by attributing to the animal a power of changing the number at pleasure. His words are remarkable:—"Although it is easy enough to count them in *some* positions, the observer may have to exercise a good deal of patience before he is certain whether they are five or six. *For a long evening only five could be discerned in the specimen now described, but on the next night six were apparent without difficulty or doubt*" ("Marvels of Pond Life," p. 81). This is sufficiently precise, and Mr. Slack is an excellent and careful observer; yet surely the power of altering the outline of the front, implied, cannot be admitted without reluctance by one who is acquainted with the animal.

somewhat rising, so as to give a trumpet-like contour to the outline.

One of the angular projections of the disk is considerably higher than the rest, and this is the dorsal one; so that the plane of the five knobs is not horizontal, but oblique, facing forwards.

A very remarkable feature in the animal, and one to which it owes much of its peculiar elegance, is that each knob is beset with straight bristles, of exceeding slenderness, and of great length, which are not set in one plane, but radiate in every direction. Ehrenberg says, there are from five to eight on each angle, but probably the poverty of his instrument deceived him. I have counted from forty to fifty on one knob. When the animal contracts, all the bristles are drawn parallel into a single pencil, and concealed within the body; and this arrangement is well seen as they slowly protrude, in the act of eversion. They are motionless when expanded, but while protruding, and in the instant of expanding (falling, as Mr. Slack well says, on all sides in a graceful shower), the pencil is seen to be agitated with a close and rapid thrill or wave, which runs along it, and looks much like the flickering of a candle-flame. It ceases the instant the disk is expanded.

The Case.—Like the *Stephanoceros*, the *Floscularia* is a householder, dwelling in a tenement of her own construction, which, if not very strong and stable, at least serves her turn. It is a gelatinous tube of considerably greater diameter than the animal's body, attached by its base to the stem or leaf of some water-plant, and standing erect with an open mouth. Its outline is even, that is, not thrown into those strong transverse folds which that of the Crown-wheel displays,* and in itself is so evanescent that it can only be discerned with difficulty as the slightest possible film, when clean. When old, however, it takes a dull yellowish hue, and becomes conspicuous, from the multitudes of minute *Navicules, Monads, Microglens,* and other organisms, and atoms of floccose sediment that are attached to, and imbedded in, the evidently viscid surface. The upper edge or brim can rarely be detected at all: in instances in which I have seen it, it was irregular and ragged, and so flexible that when the animal suddenly and forcibly contracted, the margin was drawn in after it, inverted for a short distance by the force of the vortex. It was evident that its substance was thin, inclosing a free cavity, and not solid up to the skin of the animal, as in *Stephanoceros*. A curious contretemps once showed me this. A little *Pleurotrocha,* a vagrant wheel-animalcule of another kind, roving about in the inquisitive manner common to its family, visited an expanded *Floscularia,*

* In one example, I have seen the case of *Floscularia ornata* lying in a multitude of minute and close-set transverse wrinkles.

and actually intruded into its disk; yet it was not till after several seconds that the Floscule, perhaps taken aback at the insult and deprived for the moment of its presence of mind, contracted itself. Presently it did, however, and that vigorously, when the rush of inflowing water carried the unprepared *Pleurotrocha* before it, quite into the tube. Here it began to make efforts to regain liberty; yet not, as might have seemed obvious, by the way it had entered, but through the side of the case. His pushings showed that this was thin, soft, and flexible, though sufficiently tough to resist his efforts, till at last he found his way out by the regular road.

The case is doubtless, as with *Stephanoceros*, an excretion thrown off from the skin, and moulded to its cylindrical form by the movements of the body on the foot-base, as a pivot.

THE NUTRITIVE SYSTEM.—The long bristles do not appear to have any power of forming currents in the water, not even in that subordinate degree which we have seen exercised by the *Stephanoceros*, in maintaining a sort of vortical prison, in which the victims are kept in ward. Yet there is a distinct vortex in the disk of the Floscule, and minute organisms are drawn into it from a considerable distance, and whirled round and round till they are swallowed. On the admixture of carmine or indigo with the water in the live-box, there is seen within the concavity of the disk a vortex, which takes an oval form, the longer diameter of which is perpendicular, and whose plane is from right to left of the animal.

The whole of the upper part of the body is lined with a very sensitive, contractile, partially-opaque membrane, which, a little below the disk, recedes from the walls of the body, and forms a *diaphragm* with a highly contractile and versatile central orifice. At some distance lower down another *diaphragm* occurs, and the ample chamber thus enclosed forms a kind of *crop*, or receptacle for the captured prey. Below the second *diaphragm* is another capacious chamber, which we must consider as a stomach, since digestion evidently commences in it, and it opens into the intestine.

The *mastax*, or bulb which ordinarily incloses the jaws,* is wholly wanting: the dental apparatus, which is very small, evidently springing from the common wall of the stomach, just below the second *diaphragm*. That this absence of the *mastax* is real, and not illusive, is proved by the facts that the *Infusoria* swallowed pass into the stomach, where they accumulate in its wide cavity; that the jaws are seen to act on one and another, according as they come within reach; and that after such action they pass off again into the same cavity, to undergo another

* See pp. 34 and 35, notes.

mastication, when chance again brings them within reach of the teeth.

From the ventral side of the ample *crop* that precedes the stomach, there springs, in *F. ornata*, a perpendicular membrane or veil, extending partly across the cavity.* This is free, except at the vertical edge, by which it is attached to the side of the chamber; and being ample, and of great delicacy, it continually floats and waves from side to side. At the bottom of this *veil*, but on the dorsal side, are placed the jaws, consisting of a pair of curved, unjointed, but free *mallei*, with a membranous process beneath each (fig. 1).

A large *Floscule*, eagerly feeding under my observation, presents the following phenomena:—In the water there are numbers of the green *Euglenæ* of different species, such as *E. rostrata* and *pyrum*, and of the beautiful *Chlorogonium*. These, roving near the expanded disk, are seen to be drawn into the funnel, though the long setæ remain perfectly motionless. After being hurled to and fro in the funnel awhile, the granular membrane closes suddenly upon them, and in the same instant the *Floscularia* contracts itself forcibly, extending again immediately.

The interior is now seen to be in active motion, no doubt masticating the *Euglenæ*, but the opacity does not permit the process to be distinctly discerned. In this specimen the upper half of the viscera was of a rich green, doubtless from feeding on these organisms; the lower viscera were deep red-brown.

While I held my watch in my hand five minutes, I watched just twenty animalcules engulphed, of various kinds, mostly small; these were accidental stragglers, scarcely any being visible at any one time in the field. It seems to be a successful preyer; an animalcule coming within half the body's length is sure to be involved, and once in, it rarely gets out.

The Circulation and Respiration.—No contractile bladder and no system of ciliated tags, such as I have described in the previous paper, have I ever been able to discover in this genus, nor has any other observer, so far as I am aware, except Dr. Leydig, who describes and figures a small bladder in *F. cornuta*.† I have, however, seen traces of a very remarkable vascular system, which I have some reason to think exists in *Stephanoceros* also, perhaps in connection with the tortuous threads, perhaps independent of them. This I will describe.

* Dr. Dobie considers this waving *veil*, in his *Floscularia cornuta*, to be a slit in the *diaphragm*, fringed with vibratile cilia, the motion of which, as he thinks, gives rise to the peculiar serpentine movement always observed at this point.—(Ann. Nat. Hist., 1849.)

† Sieb. and Köll. Zeitsch.; July, 1854. He assigns it, however, to the *ventral* side, which certainly is not where I should expect to find it, if present.

Dr. Dobie had observed,* in *Flosc. cornuta*, immediately below the integuments, groups and lines of very small granules continually in a state of rapid molecular motion, in appearance exactly resembling the molecules in the cusps of *Closterium*. Besides the molecular, they are subject to another motion, for occasionally they move from one part of the surface to another, in currents not very distinct nor persistent, and in no definite direction. He has seen these granules running in lines down the foot, and collecting in groups.

In both this species and in *F. ornata* there are to be seen well-defined clear bands permeating the disk in a symmetrical manner; and in a specimen of the latter I saw that these are very distinctly vessels, with walls, in which minute globular granules are suspended in a hyaline fluid. (See plate ix., fig. 1.) They have no proper circulatory motion, but the muscular movements of the animal change the position of the granules, and drive them to and fro, so that the form, direction, and dimensions of the canals can be easily perceived. Especially in the moment of expansion, after the contractions, which are almost every instant occurring in this sensitive creature, the granules are propelled with force up the canals, and in particular through the central vessel of the dorsal ray of the petaloid disk into the angle, where they accumulate, and thence through a circular vessel around the edge of the terminal knob. In this latter vessel a tremulous motion often remains among the granules after those in the other vessels have subsided to rest. The order of the vessels, so far as they can be discerned in the dorsal aspect, is as follows:—A rather wide vessel encircles the neck or constriction below the disk; thence perpendicular tubes, one in the centre of each petal and one intermediate, go off to join the marginal vessel of the disk, which follows the direction of the edge, and which sends off small circular vessels to the terminal knobs. From the lower side of the cervical vessel similar branches proceed downwards, and join a transverse but undulating vessel that appears to run along the line at which the granular and sensitive membrane relinquishes its contact with the internal skin of the body, and folds inwards to form the first diaphragm. Posterior branches are in turn given off from this, which interlace and anastomose in their course down the walls of the body, forming a loose network, with long meshes (much less distinct, however, than those of the anterior region), which unite at length into a single vessel that penetrates the slender elongated foot, even to its extremity, for I saw a single granule of the same kind as those of the anterior vessels close to the base of the foot, and a cluster of them a little below the junction of the body.

* "Annals Nat. Hist., Oct. 1849."

THE NERVOUS SYSTEM.—I have not been able to find any trace of a brain in any of the species of the genus. Two eyes are discernible in the new-born young, and even in the embryo some time before maturity. I have also, by using reflected light, detected these organs in half-grown individuals, which had well-formed and conspicuous cases. In an adult *F. cornuta* I have seen a single eye by reflected sunlight, and two in unhatched eggs, and in young that had developed the disk. The eye in the adult, *though now and then it shone out brightly, was frequently invisible* with any adjustment of forms :—so delicate and difficult are often these determinations ! In another of the same species I was able to bring out under pressure one eye, minute, but perfectly distinct, *but only one.*

Around the neck (in *F. ornata* and *cornuta* certainly) goes a band of greyish granular substance, which sends off threads toward the margin of the disk, and in some specimens may be traced running as an evanescent thread around the edge, close to the marginal vessel. These may be, and probably are, threads of nervous matter.

THE MUSCULAR SYSTEM closely resembles that of *Stephanoceros,* but it is much less distinct. The action of muscular threads stretching across the clear disk to the knobs and intermediate points, whereby different parts of the outline are twitched inwards, and the whole more or less collapsed, can often be seen.

THE REPRODUCTIVE SYSTEM AND DEVELOPMENT.—The organs of reproduction, so far as known, agree with those already described. The ovary, a large translucent organ, nearly fills the ventral half of the body, and may generally be recognized either by its immature eggs,—clear spherules, each with its nucleus,—or by a great semi-opaque developing egg, as yet soft and shell-less, in the lower part. On being extruded, the eggs, now clothed with a hard and brittle shell, of a long-oval form, accumulate in the case, sometimes adhering to the foot and body of the animal, sometimes to the interior wall of the case (plate ix., fig. 1).

Several hours after being laid, the egg-shell bursts, and the infant *Floscule* makes its appearance. It is a white, cylindrical maggot, blunt at the front end, with a central orifice, whence protrudes a short brush of cilia; but the margins are capable of unfolding, when the cilia are seen to form a whorl around the truncate summit, swiftly rotating (fig. 2). The margin soon begins to bud forth the little knobs, around which the cilia are gathered; these quickly increase in length, and the angular flower-like disk gradually forms (fig. 3). Meanwhile, the little creature, which was at first free, attaches itself by its hinder end, and assumes the conditions as well as the form of the parent. The case, however,

is not discernible till adult age: though, doubtless, it begins to be excreted early.

As in the adult, the long bristles are perfectly motionless in general, but there are short cilia distinctly vibrating on the margin. The little animal in this stage frequently contracts itself: the jaws are plainly seen, and are often open and shut.

Nothing has yet been discovered of the male sex, if it differs, as is in all probability the case, from the female.

Ehrenberg described and figured a second species, which he named *F. proboscidea*, with the following remarkable character:—"Out of the centre of the six-parted, sometimes apparently five-parted, wheel-organ [disk] projects a great cylindrical, somewhat flexible tube, which seems to have a large opening in front. The anterior end of this snout-like tube, as well as the knobbed points of the wheel-organ, carries long inactive cilia [bristles], which rotate strongly only partially, when they bring food." This species has not been seen by any other observer, and there is some suspicion that it was the result of defective observation: yet as the eminent professor says he found many specimens, and on two occasions, we must not hastily reject it. It occurred on the leaves of the water-violet, in a ditch near Berlin.

In 1849, Dr. Dobie described two other species under the names of *F. campanulata* and *F. cornuta*. The "Micrographical Dictionary," indeed, speaks of these as "doubtfully distinct;" but without reason, for having repeatedly met with both, I can vouch for the accuracy of Dr. Dobie's descriptions and figures, and for the permanence of the species.

The former (see plate ix., fig. 4) differs from *F. ornata* in the great breadth of the disk, as compared with the body. It forms a wide, shallow funnel, the edge of which projects into five very obtuse points, without knobs, the dorsal one broader and higher than the rest, and frequently arched inwards. All the points are beset with the usual radiating bristles. The dorsal projection I have occasionally noticed to present an appearance of perforation, but it may have been illusive. A clear, round, well-defined space will sometimes form in the midst of its area (see fig. 4), of which not a trace can be discerned before or after. All round the edge of the disk there passes a narrow band of granular tissue, which seems to be a continuation of the sensitive contractile membrane which lines the upper part of the body, and forms the crop; for it may be traced along each side of the neck (in this species a distinct broad collar), to the margin of the crop. It has thickenings at the angles of the disk, and at the constrictions of the collar.

The ciliary vortex, as in *F. ornata*, brings in animalcules to the funnel-disk. If they are not carried far in, the margin

makes a slight and momentary contraction, by which the prey is forced downward; but more commonly the sensitive tissue that encircles the first neck contracts upon the prey, and keeps it from escaping, until the centre of the diaphragm can grasp it, which is but the work of a moment, when it passes into the crop with a quick, swallowing motion. This cavity commonly holds several animalcules; I have seen a little *Euplotes* (an infusorium of unwonted vigour and high organisation) engulphed, and crawling rapidly about by means of its hooked feet for some time, the jaws of the Floscule remaining still, as if despairing of dealing with it until its activity ceased, which it did after a while. Generally the prey introduced is immediately brought to the jaws, which then work upon it, pounding it as it were with the points of the teeth. For some time this seems to make no impression, but by and by we discern that the surface of the animalcule is indented, and that it is growing shapeless; it is then returned to the upper portion of the stomach, where digestion appears to go on, as this part of the viscus is of a rich green hue, derived doubtless from the juices of the coloured organisms. The lower or intestinal portion is of a brownish colour, and turbid.

I have not seen the eggs of this species; but half-grown young ones, in which the dorsal angle was very prominent and horn-like (see plate ix., fig. 5), I have found in the angles of the leaves of a water-moss. The full-grown animal is one of peculiar elegance.

The Horned, or Fingered Floscule (*F. cornuta*) of Dobie (see plate ix., fig. 6), has been elaborately described by Leydig (in 1854) as if new, under the name of *F. appendiculata*. I also met with it, and described it in MS. (in 1850), before I was aware of Dr. Dobie's Memoir. The substantial agreement of three descriptions, each independent of the others, satisfactorily establishes the species. It agrees, however, with *ornata* in all points, except that the dorsal projection of the disk is furnished with a slender, erect finger behind the knob. This is constant, even the young displaying it as soon as the disk is formed. It is seated on a fleshy pedestal projecting behind the dorsal lobe, just below the knob, which, as in *ornata*, is higher than the rest. The finger is not ciliated, nor does it appear to be separately moveable; it has always a wavy course. It may possibly represent the antenna.

The case, according to my experience, is exceedingly difficult to see, nor have I been able to discern the least definition of outline, but only a slight granulation, which is moved when the animal rapidly retracts itself. The eggs are laid to the number of seven before there is any appearance of life in the embryo. They usually hang around the long foot, rather low down; but

are attached, not to the foot, as in *ornata, but to the interior of the case,* which is thus seen to be very thin. The development of the young does not materially differ from what has been remarked in the other species, except that the wreath of infantile cilia is larger and longer.

EXPLANATION OF THE ILLUSTRATIONS.

Plate ix., fig. 1, represents an adult *Floscularia ornata*, viewed from behind, magnified two hundred diameters. Eggs in various stages of maturity are seen clustered around the foot, and one egg-shell, from which the young has escaped. Fig. 2 is a young one soon after birth; and fig. 3, one farther advanced.

Fig. 4 represents the disk and upper portion of an adult *F. campanulata*, viewed from behind; and fig. 5, the young half-grown, of the same.

Fig. 6 represents the disk and upper portion of an adult *F. cornuta*, viewed sidewise. All the figures are taken from the life.

REMARKS ON THE NATURAL HISTORY OF COTTON.

By Edwin Lankester, M.D., F.R.S.

THE interest that just now attaches to the question of the supply of the raw material for our great staple manufacture will perhaps be deemed a sufficient apology for a few remarks on cotton from a natural history point of view. The discussion of this subject may also draw attention to the advantages to be derived from the study of the natural history and relations of this important product to other natural productions, by those who cultivate and manufacture it. It must be obvious to every one, with regard to the raw materials of our great manufactures, that it is but prudent that we should not be dependent on one nation or one country for our supply, as political events or unfavourable seasons may cut off or shorten that supply, to the interruption of business, or the production of great national disasters. In such a condition, however, we are nearly placed in this country by our dependence on America for the chief article of our manufacturing industry. We can only expect to repair this error by an intelligent study of the nature of the plant which yields us cotton, and especially the conditions which are necessary for its successful cultivation in other parts of the world. It is not sufficient that we are anxious to grow cotton in other places, or secure it from other sources; before we embark our capital in such an enterprise, we must understand the nature of the soil and climate in which the cotton-plant of America is cultivated, and seek to introduce it in those countries which promise to fulfil all the requirements necessary for its successful production. The past history of our attempts at introducing the culture of our commercial products is full of interest and instruction. In our efforts to introduce the silkworm into India we have failed, because we have not studied the habits of the silkworm, having expected that the peculiar species of China and Europe would feed on the plants which afford nourishment to the wild species of India. The failure of the cultivation of silk in England has arisen from the neglect of observation that the mulberry of England was a different species from that on which the silkworm was fed on the Continent of Europe. The expenditure attendant upon the introduction of the Merino breed of sheep into England might have been spared, had the habits and climate in which that animal flourished been studied

Isabel West. ac.

W. West. imp.

Cotton.

before extensive flocks were purchased and attempted to be reared in this country. These, and a hundred other facts, show how important is the study of the natural history of the materials which are employed in our national industry.

What is true of the production of the raw materials of our manufactures, is also true of the nature of the material; just in proportion as the workman is acquainted with the properties of his tools, and the materials on which he works, will he be enabled to improve his manufacture and increase the comforts of the community for which he labours. The great advances in our manufacturing industry, and the improvement of the articles manufactured, have not arisen so much from demand on the part of the public, as from the intelligent investigation of the properties of the raw materials of our manufactures, and their relations to the great physical forces of nature which man employs as his servants in the huge workshop of the world. It is, then, to the natural history of the cotton-plant and the properties of cotton that I wish more particularly to draw attention in this paper.

We have no knowledge of the precise time at which cotton began to be used by mankind; but there can be no doubt of its having been employed by the Hindoos earlier than any other race of men. The Jews were not at all, or only incidentally, acquainted with cotton. The cotton-plant grew wild in ancient Egypt, and may have been used occasionally for the manufacture of exceptional articles of general use or clothing; but the cloth in which they wrapped their mummies, and which they wore as clothing, was made from flax. We are told by Herodotus that the mummy-cloth of Egypt was made of the Byssus, and commentators down to the beginning of the present century regarded the Byssus as the production of the cotton-plant. It was left for Mr. Bauer, the distinguished natural-history artist and microscopic observer, at the suggestion of Mr. James Thomson, of Manchester, to discover that the mummy-cloth of Egypt was composed of linen, and not of cotton fibres. We are thus driven to the conclusion that Hindostan is not only the native country of the cotton-plant, but that it is the country in which its manufacture was invented and developed. Dr. Royle tells us, in his "History of the Use of Cotton in India," that its manufactured products, and even the process of starching it, are referred to in the Institutes of Menu, at as early a period as 800 years B.C. It is an interesting fact for us to know and dwell upon, at the present moment, that India is the true home of the cotton-plant, and the parent of its manufacture.

Without entering further upon the introduction of cotton fabrics and the cotton manufacture into Europe, let us inquire into the nature of the fibre that has thus found its way

from the banks of the Jumna and the Ganges to the valleys of Yorkshire and Lancashire, and become the source of a manufacture the largest and most important with which the world is acquainted. The weaving of fibres seems to have been a very early human art; the fig-leaves of our first parents must soon have given way to the rude intertwining of the woody fibres of the softer parts of plants. Amongst barbarous tribes at the present day, we find, however slender may be their habiliments, that these are generally composed of some forms of the woody fibres of plants. These fibrous garments are composed, however, of materials essentially different from cotton; and when we examine the simplicity of the means of procuring and manufacturing the one as compared with the other, we cannot but feel that the introduction of cotton as an article for making wearing apparel indicates a very considerable advance in civilization. For the purpose of understanding the difference between cotton and other fibrous materials, we must enter a little into the history of the structure of plants.

All plants are made up of two kinds of tissue, one called vascular, the other cellular. They both originate in the same processes of growth. The vascular tissue is composed of long fibres, which lie together in bundles, and form the hard and elongated parts of plants. If we take a leaf and examine it, we find a number of ribs passing off from each side of the leaf-stalk, which is prolonged into the leaf. These ribs are composed of vascular tissue; and if we take a leaf and pull one of these ribs to pieces with a couple of needles, and place it under the microscope, we shall easily discern the long fibres of which it is composed. Such fibres are found in the bark and stems of plants (pl. xi., figs. 26 and 27); and if we take any delicate plant and treat it as we did the leaf, we shall find the same fibres. When these fibres are plain and straight, without any markings, they are called plain vascular tissue, or woody fibres. Now, it is these fibres, abounding in the bark and stem of the flax-plant (pl. xi., fig. 25) and the hemp-plant (fig. 24), which yield the material of our linen and hempen manufactures. The fibres of a vast number of other plants are used in various parts of the world for the same purposes. In this country we employ the fibres of New Zealand flax (fig. 23), of jute, Manilla hemp, and cocoa-nut (fig. 22). The vegetable kingdom presents us with an infinite store of these fibres, and many more plants will undoubtedly contribute their share, as advancing civilization causes their properties to be better understood and appreciated.

Cellular tissue, which consists of variously-shaped cells united together, everywhere fills up the interstices formed by the vascular tissue (figs. 26 and 27). It also covers over the whole of

the outside of the plant, forming what is called its epidermis (fig. 23). It is in this epidermis that we find the little pores called stomates, which allow the fluids absorbed by the roots of plants to pass out. It is also upon this epidermis that we find growing those little projections which give a character to the surface of plants, as warts, hairs, prickles, and the like. In this respect the plant is like the animal, for it is from the epidermis of the animal that we find those appendages formed which we know by the name of scales, hairs (fig. 28), feathers, quills, and so forth.

All these epidermal organs in the plant are composed of cellular tissue. The cells of these hairs are very delicate and feeble, and possess very much less power of resistance than the woody fibres. However long these hairs may be, they never possess strength enough for manufacturing purposes. They will not bear the twisting that is necessary to the production of a thread which can be woven. Many plants yield long hairs, as our own cotton-grass (fig. 19) and the silk-cotton (fig. 20) tree of the West Indies; but it is found impossible to twist them into a thread for the manufacture of textile fabrics. It is, then, very strange that we should find cotton belonging to this group of vegetable organs. Nevertheless, this is the fact. The cotton fibre is a hair: it does not, however, grow on the surface of the plant. Just as we find in animals, the epidermis continued into the internal cavities of the body from the outside, so we find the epidermis of plants continued into the interior of their fruit and on to the surface of the seeds. This is a very rare occurrence; but in the case of the cotton-plant, it produces in the interior of the fruit, upon the surface of the seeds (fig. 16), a longer and stronger hair than any found upon the external surface of plants. But it is not the length nor the strength of the hair alone which gives to it the power it possesses of forming a thread when twisted. If examined under the microscope, the cotton-hair will be found apparently to consist of two delicate transparent tubes (fig. 15),—the one twisted round the other, so as to have the appearance of two pieces of cord wound round each other. If, however, the hair be examined in its young state, it will be found to be an untwisted cylindrical tube. It is during its growth that this change takes place. As the seeds and hairs grow, the capsules do not appear to expand with equal rapidity; and, consequently, the hair is exposed to pressure on all sides. The result of this is, that the hair collapses in the middle, leaving a half-formed tube on each side. These uncollapsed portions of the hair give it the "appearance," says Bauer, "of a flat ribbon with a hem or border at each edge." The hair does not, however, grow out straight, but, coming in contact with other hairs and the sides of the cap-

sular fruit, it becomes twisted; thus acquiring the appearance at first described, of two cords twisted together.

This twisting is undoubtedly the great fact that makes the cotton-hair of value to man. There are many hairs, such as those of the Cotton-grass and of the Bombax, which are as long, and, apparently, as strong as those of the Gossypium; but which, failing in this irregularity of their surface, are utterly incapable of being twisted into a thread or yarn. The twisting then gives the capacity to the cotton-hair of uniting with its fellows, and forming together a cord strong enough to be woven. If we place a portion of cotton thread under a microscope, we shall see that the projections of one portion of the hair are received into the depressions of the other, and thus they are held together by the natural inequality which has been produced on the cotton-hair by its peculiar method of growth. It is, perhaps, not unworthy of a moment's reflection, that the staple manufacture of one of the greatest countries in the world, and the principal produce of another, should depend upon the apparently accidental irregularity on the surface of a hair. But this is not accidental; the form of the cotton-hair depends upon the same forces, and is determined by the operation of laws as grand as those which arrest our attention in the movements of the physical universe. The observation of such phenomena as those of the structure of the hair of a plant, and its connection with the social and commercial conditions of two great countries like England and America, should lead to the reflection that it is to a considerable extent upon the minute and accurate study of the laws and properties of the objects in the world in which man is placed, that God has caused his material happiness and advancement to depend.

The manufacturer values cotton according to its *length*, *strength*, and *silkiness*, and the longest, strongest, and softest cotton fetches the highest price. These qualities are easily judged of by the hand and eye. At the same time it has always appeared to me, that as at least the qualities of strength and silkiness must depend on properties that can be easily observed by the microscope, this instrument might be of important use in ascertaining those qualities which render cotton of value to the manufacturer. I have been supplied with a series of commercial cottons by Mr. W. Chambres, of Liverpool, and having placed them under the microscope, I find considerable difference in the appearances which they present. The long Sea-Island cotton is a flatter and less twisted hair than any of the cottons of inferior price. I have not been able to pursue the subject so as to arrive at any positive results; and rather refer to the subject here to induce some of the readers of the *Popular Science Review* to undertake the subject, with the view of detecting the dif-

ferences which exist between the high-priced and low-priced cottons, and those which are useful for one purpose rather than another.

The hairs of the cotton plant are made of the same materials as all other parts of the plant. Whether the tissues of plants are ultimately disposed in the form of cells or of vessels, the raw material of their construction is the same. The cells and vessels of plants are made of a material called *cellulose*, —at least, this is the name given to the matter out of which cotton-hairs are formed. When we take a piece of wood, and, sawing it, collect the dust and obtain the chemical substance out of which the vessels that formed the wood were made, it is called *lignine;* and when the cells get very hard indeed, as they do in cherrystones, the material is called *sclerogen*. But these three things differ but little from one another; and the first name will serve us to distinguish everywhere the matter out of which cells are formed, and which is found in those of the hairs of cotton. Cellulose is insoluble in water, either hot or cold. Herein it differs from the material out of which animal cells are formed, for this is soluble in hot water, and is called *gelatine*. It is the insolubility of cellulose which makes it so useful to man in the manufacture of textile fabrics, and in the building of houses and ships. Although insoluble, it is easily convertible into starch. By pouring sulphuric acid on to cotton-hairs we can convert them into starch. It was at one time the dream of the chemist to be able to convert deal boards into Suffolk dumplings; but the feat has yet to be accomplished. Nevertheless, cellulose can be detected by its ready conversion into starch, and its affording then the reaction of starch with iodine. This experiment may be readily performed with a piece of paper, which is cellulose.

This cellulose, then, has a definite chemical composition, and can be changed in its properties and qualities by combining it with other things. One of the most remarkable chemical changes which it undergoes is its conversion into a rapidly combustible agent by the action of nitric and sulphuric acids. If we take a quantity of cotton, and immerse it in a mixture of these two acids, and then take it out and wash it in water and dry it, we shall find that, chemically, its character is entirely changed; although, under the microscope (fig. 18), it has lost little of its original appearance, its inflammability has vastly increased. It is, in fact, *gun-cotton*. We are indebted for the discovery of this agent to Schönbein, the Swiss chemist, whose name is so familiar as the discoverer of ozone. Gun-cotton is technically called *Pyroxylin*, a name significant of its combustible nature. Cellulose consists originally of nearly equal proportions of carbon, oxygen, and hydrogen; but, by plunging it in the acids,

it is deprived of a large proportion of hydrogen, and nitrous acid takes its place. The consequence is, that so large a quantity of oxygen is contained in the compound, that the moment it is brought in contact with heat, the oxygen combines with the carbon and hydrogen, and an immense quantity of carbonic acid gas and vapour of water are formed, and an explosion is the result.

Pyroxylin differs from gunpowder in many respects. In the first place, it ignites at a temperature of 400° Fahr., which is 200° less than the degree of heat at which gunpowder explodes. Then its explosive force is three times as great as gunpowder. On this account it is not adapted for guns; it blows them to pieces, and has, after all, a less propulsive effect on the ball. Nevertheless, for blasting, gun-cotton is very useful, and is much employed at the present day. It has also this advantage in mines—the gases it produces are less injurious than those produced by gunpowder. It resists the action of water, and, if plunged into it, or exposed to the action of damp air, it regains its explosive force by drying.

Pyroxylin has many curious chemical properties, an account of which my limited space will not permit me to give; but there is one so interesting, on account of its practical importance, that a natural history of cotton would hardly be complete without mentioning it. I allude to the solubility of gun-cotton in ether: it is insoluble in water and in alcohol, but it is soluble in ether. When dissolved thus, it is called *Collodion*. When collodion is spread on any surface and exposed to the air, the ether evaporates, and a delicate transparent film of pyroxylin is left. When iodide of potassium is added to collodion, and spread on a glass plate, and then dipped into a solution of nitrate of silver, an iodide of silver is formed, which, on being exposed to the action of light, undergoes a change of colour. By these means sun-pictures, formed by the camera, may be impressed upon the plate. These, properly prepared, become the negative plates by which the photographer multiplies, on sensitive paper, the pictures he has taken. Here again we trace the reward following upon diligent search into the properties of natural substances.

The study of the chemical properties of the cotton-hair has not only led to the multiplication of natural pictures, but to the reproduction, at a cost which places them within reach of almost the poorest in the land, of the great works of genius which no mere copies of natural objects can equal.

Before leaving the subject of the cotton-hair, there are one or two other points to which I would refer as worthy of notice and investigation. It is well known that vegetable fabrics receive different impressions from the colouring substances with which they are dyed. Cotton, hemp, and jute, when

exposed to the same dyeing agents, do not present the same colours, and these are again very different from the colours received by animal substances. This probably depends on the action of the colouring substance on the materials of which the fabrics dyed are composed. In the cotton it has been observed that the dye is not diffused through the wall of the cell forming the hair, but that it passes through the cellulose envelope, and is deposited in the interior. It would be interesting to know more on this subject, as it is probable that some kinds of cotton, whose structure might easily be made out by the aid of the microscope, receive into their interior with greater facility than do others the colouring matters which constitute their value after having been submitted to the calico-printer.

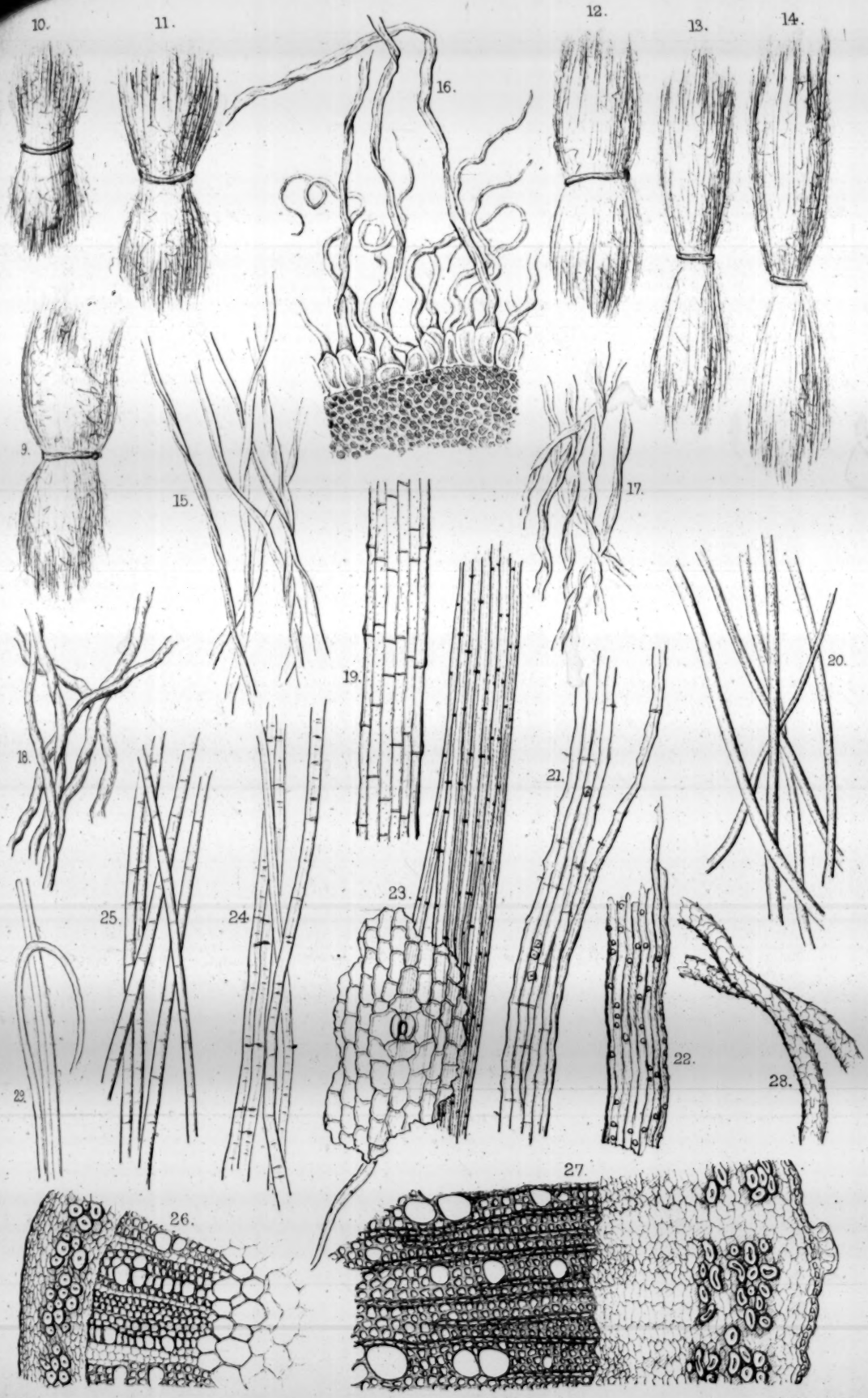
One of the most remarkable applications of a knowledge of the action of chemical substances on cotton is the process invented by Mr. Mercer for modifying its fibre. This process consists in the steeping the cotton-hair in a solution of caustic soda. The effect of this is, to alter not only the microscopical appearance of the cotton-hair, but also to change the chemical character of the cellulose. The cotton, when placed under the microscope, after having been submitted to the soda, assumes a tubular appearance, losing its flat, ribbon-like, and twisted character. The cotton thus affected is also found to have its relation changed to the various dyes to which it is submitted. Under these circumstances, it is much more easily dyed, and exhibits brighter colours than when in its unchanged state. This process is extensively employed in the manufacture of cotton stockings, more especially for foreign markets. The stockings are first made loose, and after submersion, they contract, and assume a much smaller and more elegant form. This process does not appear in any manner to interfere with the strength and durability of the manufactured article.

Another point of some interest is the chemical composition of the ashes of the various kinds of cotton-hair. It is well known to the vegetable physiologist, that certain salts or mineral substances enter into the composition of the tissues of plants, and, unless these substances are supplied to the soil, the plants will not flourish. It is on this principle that the farmer now applies phosphate of lime to his land, because his cereal crops will not grow so well without it. This constituent is present in the grains of wheat, and is conveyed to the bones of man from the flour of wheat, which he eats in the form of bread. The sugarcane requires silex, or flint, in its stems, and the sugar-cultivator has found it of advantage to manure his crops with powdered glass, which contains the silex needed by the sugarcane. I throw out this suggestion because circumstances might occur to render it of im-

portance to supply artificially to the soil the constituents necessary for the production of the cotton in its greatest perfection. It may be found that the difference between the production of the most valuable cotton and that of an inferior description, depends on the supply of those mineral constituents to the soil which are necessary to the proper development of the cotton-hair. It has been stated that the ashes of the finest Sea-Island cotton contain a larger proportion of the salts of potash, whilst inferior kinds contain larger quantities of soda. Such facts are of high interest to the cotton cultivator, and seem to point out the way of securing the better qualities of cotton.

But let us now turn our attention to the history of the plants which produce this wonderful hair. The genus of plants which yield cotton is called by the botanist *Gossypium*. This word, which is the Latin word for cotton, is said to be a corruption of the Egyptian word *gotne*, which is evidently a form of the Arabic *kutun*, and has its origin in the same root as our word cotton. This botanical genus *Gossypium* embraces several species, four or five of which have been named by botanists as affording the cotton of commerce. The family or group of plants to which the genus *Gossypium* is referred, is the Malvaceæ or Mallow tribe. This family of plants is remarkable for its showy flowers, and embraces about thirty-five genera in addition to Gossypium. Some of these are well known. Besides the common mallow and the round-leafed mallow, which are common on all our waysides, the marsh-mallow is a British species. In our gardens the hollyhock is a familiar example of the size, and beauty, and colour of the flowers of this order. If we examine one of the flowers of these plants, we shall find that a distinguishing feature of them is that the stamens are all united together, forming a column in the middle of the flower, which is hollow in the centre, and surrounds the styles, which proceed from the germ or ovary in the middle of the flower. These columnar stamens are characteristic of the family; but there is a further mark of brotherhood in this Mallow family, and that is, the anthers having but one cell. Usually the anthers, which are placed at the top of the filament of the stamens, have two cells or compartments, in which the pollen-dust is kept; but in the Mallow tribe each stamen keeps its pollen in a single cell. There are many other points of structure about these plants which, conjoined with the above, make up very strong family features. One of these is worth notice, and that is, the arrangement of the petals. If a mallow is gathered before its flowers are opened, and the sepals of the calyx are removed from the petals, it will be found that the petals assume the appearance of having been twisted. It looks

Plate XI.



Tuffen West, sc. ad. nat.

W. West, imp.

Fibres.

precisely as though some one had taken the young petals between his finger and thumb, and given them a twist, just such a twist as a confectioner gives to the corners of a paper bag, when he has placed in it the articles he wishes to secure by this process. This is called a "twisted æstivation," and such an arrangement may be seen in the flowers of the hollyhock, the cotton, the marsh-mallow, the abutilon, and other common plants of the order.

The genus Gossypium is distinguished among other genera of the order by three leafy bracts outside the flowers, which are united at their base (pl. x., figs. 1, 2, 3), and by the seeds being covered with hairs (fig. 6). The following are the species which have been recognized, and which are known to yield the cotton of commerce:—

1. *Gossypium herbaceum* (fig. 3).—This is the common Cotton-plant of India, and is probably the original source of the hairs from which the first cotton fabrics were manufactured. It is called herbaceous, because its stems are not so woody as in the other species. It is a pretty plant, and rises from eighteen inches to two feet in height during the first year of its growth. It is usually cut down annually, but, if allowed to grow, the plant attains a height of five or six feet, and its branches become more woody. The younger parts of the stem, as well as the flower and leaf-stalks, are covered with hairs, and are also marked with black spots. The leaves are also hairy, but the hairs are very short, and different from those on the seed. The flowers of this plant are of a lively yellow colour, and each petal is marked with a purple spot near the base. These plants are described as very beautiful when in blossom. The large mass of columnar stamens is also conspicuous in the middle of the flower when it is open. The flowers are succeeded by a fruit, which gradually becomes dry, and then bursts into three or four valves, when the cotton-wool is seen issuing from the fruit in all directions. When the wool is cleared away from the seed, there will be found upon it a downy substance, which consists of a series of smaller hairs on the surface of the seed (fig. 16).

This plant not only yields a good proportion of the shorter cottons of India (fig. 10), but it is found in China and the Malayan Peninsula, and also in Egypt. A species named *Gossypium punctatum* is found in Senegambia, which is probably a variety of the *Gossypium herbaceum*. It is cultivated on the borders of the Mediterranean, and has been introduced into some parts of America.

There is a curious tendency on the part of some cotton-plants to produce a yellow or tawny cotton instead of white. This is the case with much of the cotton that is produced in

China. The colour has been no hinderance to its employment for manufacture. It receives the same dyes as white cotton; but when it is not dyed it has that yellow colour which is peculiar to what is called "Nankeen" in this country, when it is made up. This name has probably been given to it from the Chinese origin of this kind of cotton. The question has arisen as to whether the plant which produces this tawny cotton is not another species, and botanists have described it under the name of *Gossypium religiosum*. The Chinese plant which yields the yellow cotton is very like the Indian plant. It is described as being more hairy, and having its flowers of a darker yellow or brownish colour. Dr. Royle, who is one of our greatest authorities on cotton-plants, says that other species of cotton, besides the Chinese, produce tawny cotton, and he does not believe in this character as a distinction for the species of cotton.

This question of species might, at first sight, be thought an unimportant one; but when it is remembered that species are peculiarly adapted to the circumstances in which they are found, and will not submit to a change in their culture so easily as varieties, it becomes a matter of practical importance to solve such a question. The fact that the Chinese form has been successfully introduced into those parts of the world where also the Indian species flourishes, would indicate that they are varieties of the same primitive type.

2. *Gossypium arboreum* (fig. 2).—This is another Indian species, and is called the Tree Cotton. It is a very different plant from the last. It grows to the height of from fifteen to twenty feet, and assumes the aspect and dimensions of a small tree. The young and growing parts of the plant, like the rest of the species, are covered with hairs, and the young branches have a red colour. The leaves are palm-shaped, hairy, and dotted with spots of a dark green colour. The flowers are of a bright red colour, getting a little yellowish towards the lower part. These red flowers are very characteristic, and when the tree is in full blossom, give it the appearance of a branched hollyhock with red flowers. The fruit is a dried capsule, similar to that of the last species, opens with three or four valves, and is filled with a fine silky yellowish-white wool. In this case, the seeds are covered with a greenish down, in addition to the wool. The seeds in the different species of cotton differ very considerably in their colour, and in the presence of this short down; they vary also in number. The Tree Cotton is found in the island of Celebes, and is distributed through every part of India. This cotton is not, however, employed generally in the manufacture of cotton cloth, as it is regarded by the Faqueers of India as a sacred plant. It is therefore planted near temples, and also sur-

rounding habitations. The cotton makes a very fine muslin, which is manufactured into turbans, and permitted to be worn only by the privileged religious classes of India.

3. *Gossypium barbadense* (fig. 1).—This is called the Barbadoes or Bourbon cotton, but does not appear to have been originally a native of the New World. It is a perennial plant, and has a shrubby stem from six to fifteen feet in height. The leaves are lobed like those of the other species, and are often covered with short hairs on the under surface. The flowers are yellow, like those of *Gossypium herbaceum*, and have a dark spot at the base of each petal. The fruit is capsular, and contains in its interior from eight to twelve black seeds, which are not covered with any down like those of the two preceding species. Although other names have been given to the plant which produces the long Sea-Island, or long staple cotton of America, there is no doubt that this plant is the original of this valuable form of cotton. It was introduced into Georgia by seed brought from the Bahama Islands, where it had been grown from seed obtained in the West Indies. In the small American islands which fringe the coast of Georgia, from Charleston to Savannah, this plant has produced the celebrated Sea-Island cotton, which is unrivalled for the length of its staple, its strength, and silkiness (fig. 14). Its excellence for manufacturing purposes may be judged of by the fact that its price has varied from fifteen pence, at this time last year, to three shillings a pound at the present time, whilst other cottons have varied from five pence last year to about thirteen pence a pound at the present time.

The cotton which is of such excellent quality on the islands and swampy coasts of Georgia, is inferior when cultivated in the cooler and drier climates of the hill country of that state. The cotton produced in those districts is short in staple, and the seeds, instead of being black, are green. This fact shows how great is the influence of external circumstance on the successful growth of the cotton-plant. The cotton from the hills of Georgia is known in the markets by the name of Upland or *Bowed* cotton. This latter term is applied to it on account of the way in which it is prepared for the market. The wool is separated from the seeds by means of a bow with several loose strings, which is struck upon the cotton, and the vibrations produced separate the cotton from the seed. The price of Bowed cotton was last year at this time, at Liverpool, seven pence a pound; at the present moment it is worth a shilling a pound.

Under the name of *Gossypium hirsutum*, Dr. Royle and other botanists describe a species, which, although it has characters that would claim for it such a position, is, nevertheless, open to the suspicion of being a variety. It is in fact the plant

which yields the Upland cotton of the Americans. It has the short staple and green seeds of the Upland Georgia cotton, and which there is reason to believe originated in the culture of the *Gossypium barbadense*. The principal distinction upon which the botanist relies for a specific difference, is the green colour of the seeds, which is found to depend upon the presence on the surface of the seed, of the pubescence or short hairs which have been before alluded to. In the typical *Gossypium barbadense* there is no pubescence, nothing but the long cotton-hair, underneath which the seed is black.

4. *Gossypium Peruvianum*.—The Peruvian Cotton-plant, also described as *Gossypium acuminatum*, is recognized by most botanists as a distinct species. Like the Bourbon cotton, it has black seeds and yellow flowers. The seeds adhere together, however, in a peculiar way in a kidney-shaped mass; and although in other respects it resembles the last species, it has a peculiar appearance, and cannot in any way be traced to the species of the Old World for its introduction. On the conquest of Peru and Mexico by Pizarro and Cortes, it is worthy of note that in both countries the inhabitants were found to have acquired the art of weaving cotton. The species of plant from which this cotton was obtained was the present one, which is undoubtedly the only species truly indigenous in America. It is this which yields the Pernambuco and Maranham cottons of the markets. After the Sea-Island and Egyptian, these South-American cottons obtain the highest price in the market.

It becomes an important matter to ascertain what are the conditions under which the various species of cotton-plant thrive, as we can only hope to extend its culture successfully by ascertaining the external circumstances under which it has prospered, and securing them for future experiments. In the first place, with regard to *heat*. We find that the cotton flourishes best in the tropics; but its culture has been successfully extended in warm districts, in both south and north subtropical climates. It has been produced in great perfection in Egypt (fig. 9), and the islands of the Grecian Archipelago; and cotton equal to the finest Sea-Island has been produced at Algoa Bay and in Australia (fig. 13).

A second element which seems to exercise an important influence on the growth of cotton, is *moisture*. The humid atmosphere that prevails along the coasts of Georgia seems to be the circumstance, above all others, that has led to the great superiority of the Sea-Island cotton. That this is the case we may observe from the fact of the same plant, when taken to the dry uplands, producing a very different and inferior kind of cotton. It has been stated that the atmosphere of the coasts of America contains in it a considerable quantity of salt, or chloride of sodium,

and that this produces a favourable effect on the cotton. If this should really be the case, it would point to the propriety of seeking for cotton-fields on the seacoast rather than in the interior of a country.

As far as the *soil* is concerned, we find that the American and Indian species grow on very different soils. They both, however, agree in this point, that they contain a considerable quantity of organic matter, of a substance which is known commonly as mould, or to the chemist as humus. This material, wherever present, constitutes the most valuable constituent of a soil. It is highly absorbent, and supplies the plants whose roots are inserted in it, with the carbonic acid and ammonia which they need for the growth of their tissues. The inorganic or mineral constituents of the American soils, according to analyses by Professor Solly, consist of sand, clay, iron, and carbonate and sulphate of lime. These are the kind of constituents that we should expect to find on the low coasts of the shores of America. Such an analysis may guide in the selection of soils for the purposes of experimental cultivation. The Indian soils, on the other hand, on which the Indian species grow, are composed of the *débris* of trap rocks, of clay and limestone. It appears from experiments that have been made, that the *Gossypium barbadense* will not flourish on the Indian soils (fig. 11), whilst the *Gossypium herbaceum* will not flourish, or at least improve, when transplanted to American soils. This shows clearly the necessity of attending to the external circumstances which influence the growth of the cotton. This, we have seen, is not only necessary for the whole genus, but for each particular species. It is probable that the same circumstance applies to varieties, and that in the purchase and planting of seed, too much care cannot be taken to ascertain that the new circumstances of the plant should as nearly as possible resemble those in which it has previously flourished.

The great question for this country to settle at the present day seems to be, How and where shall we secure cotton for our manufactures independent of America? The recan be no doubt that the wisest and most patriotic reply that can be made to this question is, "In our own colonies and dependencies." Amongst these, India presents itself as capable of affording by far the largest supply; and it is a question of great interest to ascertain why India has not furnished the market with larger and better supplies of cotton. At the present moment Indian cotton fetches the lowest price in the market. It has a short staple, and is not brought into the market so clean as that from other parts of the world. It is, however, a serviceable cotton. A longer stapled cotton might evidently be obtained by cultivating the American species of cotton in soils adapted for its

successful growth. The cleaning it, is a matter which enterprise and intelligence ought to accomplish.*

Africa, no doubt, presents on its northern, western, and southern coasts, soils and climates adapted to the growth of cotton. Many years ago I forwarded specimens of cotton, which had been grown at Port Natal, to Manchester, and they were pronounced of excellent quality. The great difficulty, however, which Africa presents is that of securing a permanent supply of labour. The native population is everywhere too rude in its habits to be depended on for producing any large quantities of a produce requiring so much attention for its culture as cotton. It will be a happy day for Africa when its inhabitants shall settle down to the permanent production of those substances so universally needed by man, and which its soil and climate are so capable of yielding in almost any quantity.

To the West Indies we ought to look. Our own islands there were the first recipients of the plant which now supplies Manchester with its best cotton. Till the year 1786 we received above a third of all our cotton from the West Indies; and there appears to be no valid reason why we should not receive a larger quota than this at the present day. Soil and climate are favourable to the production of cotton equal to the Sea-Island (fig. 12); and there are only needed the enterprise, skill, and determination which have enabled the Southern statesman of America to obtain for his cotton access to all the markets of the world. Let it not be said that slavery is essential to the growth of good cotton, as it is very evident that this is an accident, and not a necessity of cotton culture.

The only other country to which it is necessary here to draw attention is Australia (fig. 13). Upon the coasts of this vast country there must be innumerable localities in which cotton would find all the conditions of its most prosperous growth. Already specimens have been seen in this country, and a high authority has pronounced that "cotton equal to the finest of the fine might be produced to an almost indefinite amount" in Australia. A new experiment must, however, be tried there before cotton cultivation can succeed, and that is the ability of the white labourer to meet the conditions necessary for the cultivation of a plant whose natural climate lies within and a little beyond the tropics. This difficulty may not be insurmountable, and we may yet be indebted to Australia for a commodity more precious than gold.

* Since the above was written, my attention has been called to some letters by Dr. Wight, on the subject of the culture of cotton in India, in the "Gardener's Chronicle" for December, 1861, which claim the consideration of all those interested in the culture of cotton in India.—E. L.

DESCRIPTION OF PLATES X. AND XI.

Fig. 1. American cotton-plant (*Gossypium barbadense*).
2. Tree cotton (*Gossypium arboreum*).
3. Indian cotton (*Gossypium herbaceum*).
4. Pod of American cotton bursting.
5. Pod of Indian cotton.
6. Seed from Abyssinian cotton.
7. Ditto of American cotton.
8. Pod of American cotton.
9. Bundle showing the length of staple of Sea-Island cotton (*G. barbadense*) grown in India.
10. Ditto of native Indian cotton (*G. herbaceum*).
11. Ditto of New Orleans cotton grown in India.
12. Ditto of West-India cotton.
13. Ditto of American cotton (*G. barbadense*) grown in Australia.
14. Ditto of fine Sea-Island cotton.
15. Fine Sea-Island cotton under the microscope.
16. Outside of seed of cotton, showing the down, together with the cotton-hair.
17. Surat cotton (*G. herbaceum*).
18. Gun-cotton.
19. Hairs of cotton-grass (*Eriophorum vaginatum*).
20. Hairs of Bombax.
21. Fibres of jute.
22. Cocoa-nut fibres.
23. Fibres of New Zealand flax, with a portion of the cuticle of the stem, and a stomate in it.
24. Fibres of hemp.
25. Fibres of flax.
26. Transverse section of stem of flax, showing the bundles of woody fibre in the cellular tissue.
27. Transverse section of stem of hemp, showing ditto.
28. Wool of sheep.
29. Fibres of silk.

GRASS.

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"He bringeth forth grass for the cattle, and green herb for the service of men."— PSALM civ. 14.

WHEN an untravelled Englishman takes his walk across the wide-stretched parks of his native land, or strolls over the green meadows of the nearest village, or even if his view be confined to his garden lawn only, he will hardly be aware that the turfy carpet, to which he is so accustomed, cannot be equalled in the evenness and regularity of its pile, or the greenness of its colour, in any other country under the sun.

But should our countryman go abroad, he will hear on all sides from those foreigners who may have visited England, the highest laudations of our parks and lawns; and when he is weary of foreign scenes, and sighs for home, he may know, if he but carefully scrutinise his thoughts and feelings, that his native meadows more than all besides are at the bottom of his longings, as they afford that refreshing repose to the eye and peaceful calm to the mind, which cannot be found elsewhere in an equal degree.

If again, our friend should inquire more deeply, and wish to know to what he is indebted for so much beauty, we could tell him that its immediate cause is an even, steady, luxuriant (but not rank) growth of a series of grasses, which know how to live side by side, each tending to the other's good; and while it is quite true that here and there may be seen some upstart kind trying to overtop the rest, and get a plot of ground all to itself, yet be sure there is no sweetness there, for even the quiet sheep would shun it.

But there is yet something more. Our temperate climate, in spite of all that may be urged against its mist, its east winds, or drizzling rains, has not those extremes of heat or cold, of rain or drought, which belong to other countries, and which render that continued growth of turf that we enjoy impossible.

Spicate Grasses

J.E. Sowerby, sc.

Thanks then to the Divine Author of all Good, green parks, flowery meads, and closely shaven lawns, belong to our climate, and this affords us, after all, no small balance in its favour.

Seeing, then, that the grass of the field is so important an element in all that is English in scenery, and is besides so interwoven with the economics of our daily life, we purpose devoting a few pages to the illustration of the *structure*, *classification*, *habits*, and *economy*, of the useful tribe of plants to which grasses belong.

Time was when most herbaceous plants were known by the general term of grass, and even in the present day, plants very different from those we are about to describe, are familiarly known by the word grass as a prefix, or affix, thus :—

Grass of Parnassus, (*Parnassia palustris*); scurvy-grass, (*Cochlearia officinalis*); rib-grass,* (*Plantago lanceolata*).

Science, however, insists upon a more natural arrangement, and so confines the term grass within the following description :—

Endogenous plants, with chaffy scales in place of floral envelopes (calyx and corolla). The outer pair of scales, called *glume*, or outer pale,—the *calyx*. The internal pair called *glumel* or inner pale,—*corolla*. Stamens, usually three; pistils, mostly two; *stems*, fistulose jointed—that is, a hollow jointed tube; leaves, sheathing.

As a botanical group, there is none more natural, and yet none more varied; but such variations are of the most simple kind, and when once understood, the study of this tribe of plants, far from being considered one of a difficult kind, will really become comparatively easy; for as the observed variations mostly arise from a difference in the *proportions* of parts, if we start with correct notions of the *organography* of a single species, we can have but little difficulty in applying our knowledge to the examination (analysis) of all others.

The chief distinctions of grasses may be classed under the following heads :—

a. In the size and details of the parts of the flower.
b. In the length of the *pedicels*, or the flowering stems, by which each individual flower, or bunch (*locusta*) of flowers, is immediately supported.
c. In the general size of the whole grass.

In order, then, to understand these points, it will be necessary

* One of our students was showing a farmer a collection of *all* the meadow grasses, when the latter took occasion to observe that the rib-grass was absent.

shortly to review the parts and organs, which are found in our native species of grasses. They will be as under :—

ANALYSIS OF A GRASS.

Root	*a.* Fibres	The true root fibres.
Stem.	*b.* Rhizome	The creeping underground stem.
	c. Stolon	Shoot, or runners above ground.
	d. Culm	The upright above-ground stem.
	e. Joint	A single length from node to node.
	f. Node	The solid knot between the joints.
Leaf.	*g.* Sheath	The folding portion of a leaf.
	h. Ligule	The tongue of a leaf.
	i. Blade	The lamina or free part of a leaf.
Floral Envelopes.	*j.* Glume	The outer chaff-scales } in pairs.
	k. Glumel	The inner ditto }
	l. Awn	The bristle (beard) of some species.
Fertilizing Organs. Stamen.	*m.* Filament	The thread supporting the anther.
	n. Anther	The pouch containing the pollen.
	o. Pollen	The farina or fertilizing dust.
Pistil.	*p.* Style	The support of the stigma.
	q. Stigma	The tip or end of the style.
	r. Seed	The reproductive organ.

N.B.—The letters to the analysis refer to the plates, except *a*, *b*, *c*, and *o*, which are sufficiently explained above.

Now these terms, with their references to our figures, will, it is presumed, be amply sufficient to indicate the parts of a grass referred to, without any more minute description, as it is no part of our plan to dwell upon the minute anatomical distinctions, or morphological theories that necessarily belong to this subject, which would then be rendered an abstruse rather than a popular one.

It may be well, however, just to mention that some of the parts in the foregoing analytical table will be absent in some species; their absence or presence will afford specific characters, and these are further enhanced by the different details of different parts, as whether the valves of the glume be pointed or obtuse, ribbed or plain, or those of the glumel awned, awnless, &c., &c.

With these notes on the organography of grasses, we proceed to the consideration of our next point of inquiry.

2. THE CLASSIFICATION OF GRASSES.—In treating of this subject, we would again repeat that our remarks have immediate reference to our native species. These we shall find, with the exception of three, to possess three stamens and two pistils. The exceptions are—

Anthoxanthum odoratum, sweet vernal grass, stamens 2, pistils, 2. *Hierochloe borealis*, northern holly-grass, terminal flower with stamens 2, pistils 2, lateral ones triandrous.

Nardus stricta, mat-grass—stamens 3; pistil 1.

The rest in our list of British grasses, consisting of about 40 genera and 120 species, belong to the Linnæan, *Class* Triandria; *Order*, Digynia.

Fig. a.

These it is necessary to divide into smaller groups, which may readily be done upon the following principles, dependent upon—1st, the arrangement of the flowers; 2nd, the form of the inflorescence.

1st. With regard to the relation of the glume-scales to those of the glumel, it becomes now necessary to remark that there is not always a pair of the former to each pair of the latter, as in this respect we find three points of difference, as follows :—

a. Each glume having a single flower; that is, glumel, stamens, pistil, and seed.

b. Each glume having two flowers, or two sets of glumellæ, stamens, pistils, and seeds; that is to say, that each bunch (*locusta*) of flowers consists of two florets to the single glume.

c. Each glume possesses three or more sets of glumellæ, stamens, pistils, and seeds; or, has three or more florets to a single glume.

Fig. b.

Fig. c.

2nd. A point of importance to be here observed, is that of the form of the inflorescence, as thus: each flower, or locusta of flowers, may be so closely set on the central column (*rachis*) as to form a compact head, or "spike," which may have the

florets on one side, or "unilateral," like *Nardus*, or hard grass (pl. xii., fig 1). On two sides "bilateral," as in *Brachypodium*, false brome-grass (pl. xii., fig. 2). Or on all sides, as *Alopecurus*, or foxtail grass (pl. xii., fig. 3), which forms a long or "lanceolate spike," as in *Phalaris canariensis*, canary grass (pl. xii., fig. 4), making an ovate spike.

Again, the flower or locusta may have pedicels of greater or less length, which may be short and upright, long and pendant; and so form a compact or diffuse "panicle" of flowers, which will be erect or drooping, towards *one* or *all sides*, according to circumstances. (See plate xiii.)

Of the different kinds of spike, our plate (xii.) offers several examples, whilst plate xiii. offers examples of the panicle.

Our native grasses, therefore, may be most conveniently grouped as follows :—

A. STAMENS, 2; PISTILS, 2;
B. STAMENS, 3; PISTILS, 1;
C. STAMENS, 3; PISTILS, 2;

† *Spikelets, single flowered;*
* Flowers spiked;
a. Spikes unilateral;
b. Spikes bilateral;
c. Spikes, with flowers on all sides;
** Flowers paniculate;
†† *Spikelets, two flowered;*
*** Flowers spicate;
**** Flowers paniculate;
††† *Spikelets, with three or more flowers;*
***** Flowers spicate;
****** Flowers paniculate.

Thus, we have subdivided our native grasses into nine groups, which altogether include a list of genera and species that must be expected to vary considerably, according to the principles of founding both genera and species that may be adopted by different authors,—a subject upon which, it will be seen from the following census, that there is considerable difference of opinion :—

	Genera.	Species.
Sir W. Hooker, in the "British Flora," 1842, has .	41	123
Hooker and Arnott's "British Flora," 1850, has .	44	129
Professor Babington's "British Botany," 1851, has .	50	131
Bentham's "Handbook of the British Flora," 1858, has .	42	98

Whichever number we choose to adopt as our guide in the enumeration of our native species, it will be seen that, after all, in a country so justly renowned for its pasturage, the native species form but a small proportion of the grasses of the world,

Paniculate Grasses.

which, according to Professor Lindley, amount to 291 genera, containing 3,800 (?)* species.

But this will appear in a still stronger light when we consider that, after all, the fame of the English pastures rests upon about 20 genera, including no more than 40 species, and that, even of these, probably all but about a dozen would be better out of the pasture than in it. In concluding this part of our subject, however, we would not have it supposed that grasses only are useful in the meadow, for it is well known that several herbs, and more especially the clovers, are highly valuable as part of a pasture; indeed, so much so, as to be called by the farmer "artificial grasses," a term which, after all, seems to imply a secondary position compared with the real *Graminaceæ* which, though so few in species, are yet the plants which so much charm the admirer of English rural scenery, and are at the same time of such great economic value.

3. Habits of Grasses.—We have just seen how few of this tribe of plants occupy the meadow as pasturage, and, indeed, these are not exclusively meadow-plants, for their habits are so varied as to fit them for almost every situation. Thus we have—

		Species.
Jungle or Bush Grasses, Rocky Places, &c.	about	40
Aquatic, or Water Grasses	„	10
Marine, or Sea-side and Salt Marsh Grasses	„	14
Meadow, or Pasture, or Herbage Grasses	„	35
Agrarian, Fallow, or Weed Grasses †	„	23

Now, if we estimate the number of grasses of the meadow kinds at about twenty species, we shall find that such disorders in the pasture as want of drainage, will introduce a number of the aquatic kinds, whilst a pasture being allowed to run wild will also give rise to a quantity of the jungle forms, which gradually become a part of what can only be considered as rough wild herbage.

Again, if we divide meadows according to their quality, we shall find that they contain different species, in very varying proportions, for which see the following table:—

* This note of interrogation is employed by Professor Lindley in "The Vegetable Kingdom." We must, therefore, take these figures as merely approximate.

† These numbers are derived from an allocation of the species figured in "English Botany."

TABLE.—*Showing the Relative Growth of Grasses in different Situations.**

1. Botanical name.	2. Trivial Name.	PROPORTIONAL. 3. Upland Pastures, thin Soils.	4. Poor Clays.	5. Rich Loams.	6. Flooded Meadows.	7. Irrigated Meadows.	REMARKS.
1. Alopecurus pratensis	Meadow foxtail	—	1	2	2	3	Very variable in growth, increasing rapidly as the soil becomes better.
2. Phleum pratense ...	Timothy grass	—	2	2	1	2	In poor land only about 9 in. high, 2 feet in good soil.
3. Agrostis stolonifera	Marsh bent	2	—	—	1	2	Occurs in all poor uplands, where it is generally refused by cattle. Spreads rapidly under irrigation, when it becomes a good grass.
4. Arrhenatherum avenaceum	Oatlike grass	—	3	1	—	—	Never abundant, except in poor soils either of clays or sands.
5. Poa pratensis	Field meadow-grass ...	1	1	2	1	3	In most meadows.
6. ,, trivialis	Roughish meadow-grass	—	—	—	2	1	Increases quickly in stagnant meadows; decreases under perfect irrigation.
7. Briza media	Quaking grass	1	2	—	—	—	Only in poor soils.
8. Avena pubescens ...	Soft oat-grass...	1	—	1	1	1	Tolerably constant in meadows.
9. ,, flavescens ...	Yellow oat-grass	—	—	1	1	2	Most abundant in good soils.
10. ,, pratensis ...	Narrow-leaved oat-grass	1	2	—	—	—	Often abundant in poor heathy land.
11. Holcus lanatus ...	Meadow soft grass ...	1	1	—	2	—	Increases rapidly in stagnant or marshy meadows, not usual in good pastures.
12. Festuca ovina	Sheep's fescue	4	—	—	—	—	Almost entirely an upland grass.
13. ,, duriuscula..	Hard fescue	2	1	1	—	1	Also an upland form, but occurs more or less in most places.
14. ,, rubra (var.)	Creeping fescue	—	—	2	—	—	A form, though not frequent, in rich meadows; also in sandy pastures near the sea.
15. ,, pratensis ...	Meadow fescue	—	—	2	1	1	Abounds in good pastures.
16. ,, loliacea ...	Spiked fescue...	—	—	1	2	2	Very fine in floods' way, on the banks of the Isis, at Oxford, and on the Churn, near Cirencester.
17. Bromus erectus ...	Upright brome-grass ...	1	—	—	—	—	Belongs peculiarly to calcareous uplands.
18. Dactylis glomerata...	Cocksfoot-grass	—	1	2	3	3	Of general occurrence; increases rapidly in good soils.
19. Hordeum pratense...	Field barley-grass ...	1	1	2	2	2	Often in patches in the richer parts of uplands. Very abundant in the hay-fields in the valley of the Churn.
20. Lolium perenne ...	Perennial rye-grass ...	1	1	3	2	2	In most pastures. In uplands it seldom attains to 6 in. high; it is double that in good deep pastures.
Amount of hay per acre	Average	—	10	15	25	30 to 40	
Rent per acre	Average	10	15	25	30	40 to 100	

* From the "Natural History of British Meadow and Pasture Grasses." Hamilton & Adams.

In this table are arranged twenty species of the usual meadow grasses; it will be seen that they differ under varying circumstances of soil and condition of the meadow; each species of this tribe of plants becoming, as it were, an index of the nature and cultivation of the soil; for if the latter be neglected there will soon be a change, not only in the species and their proportion of meadow grasses, but gradually there will be introduced those of the jungle list, until the meadow itself, by continued neglect, would resolve itself into jungle, heath, or moor land.

Our beautifully shaven lawns and green meadows, though so characteristic of merry England, are not natural to the country, but are, after all, the result of cultivative skill acting in accordance with those natural conditions of soil and climate which favour their development, and this consideration introduces us to the next division of our subject.

4. The Economy of British Grasses. — It is often repeated that, "he is a benefactor to his country who makes two blades of grass grow where one did before,"—a remark, of course, more particularly directed to the farmer and the country gentleman, many of whom may be justly lauded for having attempted, with some measure of success, to realize the position. Still, however, these interesting plants have been so little studied, that, after all, the progress of improvement in meadow is, and has been for a long time, nearly at a stand-still; and at the present moment the pastures of England are little more than half as productive as they ought to be, many being in need of drainage, and more requiring weeding.

Now, it may interest the popular reader to be told that some of the most mischievous weeds in meadows are grasses themselves; still, if we could but instil into the minds of those whom it concerns, that whatever takes up space without contributing nutritious matter, can only be regarded as weeds, then the rough grasses that multiply just in proportion as a meadow is out of order would be looked upon with disfavour, and as some of these kinds arise from *wet*, others from poverty, and many from neglect, the study of the natural history of this tribe of plants is calculated to inform us of every condition of soil and cultivation, even in their most minute inflexions. That meadows should be overrun with rushes, wild parsley, docks, plantains, dandelions, and buttercups, exhibits want of care; and the great prevalence of these is tantamount to a waste of land and loss of grass; for "two things cannot occupy the same space at the same time." This is not the place, however, to enlarge upon what may be considered to some extent a professional matter, and so leaving their cultivation to those concerned in it, we draw our brief survey of the grasses to a close by say-

ing that they are in themselves so beautiful, so diversified in their structure and habits, and in every way so interesting and useful, as to render their natural history well worthy of popular study.*

Before concluding, it may now be not without value if we give a few directions with regard to the collection and preservation of specimens. As the forest shades, the rocks, moorlands, salt and fresh water, meadows, and agrarian fields, have all their graminaceous denizens, no part of a district or country should remain unexplored; the specimens when obtained should be placed evenly and neatly between sheets of blotting paper, or even in old newspapers, and then put between boards and pressed with straps, or with some weight. Care should be taken to keep the specimens of the proper size for the permanent herbarium, which may be done either by cutting them into lengths, where too long, or by bending them.

It is also of importance to see that the papers of one day's collection are not put with those of the day previous, and so that three or four boards would be advisable to separate one lot from the other; for it is obvious that if a fresh lot be placed along with those that are already partially dried, the former will communicate their moisture to the latter, and then mouldiness will result. The permanent herbarium should consist of a portfolio, or of separate sheets of cartridge paper, about eighteen inches long, and eleven wide.

The summer collection and arrangement of grasses cannot fail to impart health to the body and vigour to the mind; and when winter comes, and our favourites are no longer in their prime, how pleasantly our herbarium recalls our many agreeable rambles, and as we then look out, it may be, from the windows of our cheerful country-house, and behold our parks and meadows now brown and seared, which once were so gay with waving grass, we may reflect with the Psalmist:—

"The days of man are but as grass, for he flourisheth as the flower of the field.

"For as soon as the wind goeth over it, it is gone: and the place thereof shall know it no more."

* We recently had the pleasure of examining some large and beautiful collections of our wild grasses, which were made under such interesting circumstances that we cannot forbear referring to the fact. The Messrs. Wheeler, seedsmen, of Gloucester, having for some time become aware of the importance of a personal acquaintance with the plants, the seeds of which they sold, offered prizes for competition among their commercial travellers, clerks, and warehousemen, for the best collection of wild grasses. The result was a very spirited contest, which led those engaged into scenes of beauty they would perhaps not otherwise have visited; and this made them acquainted not only with the appearance, but also with the habits of a tribe of plants, the observation of which, we venture to say, is better calculated to discipline the mind than is that of any other group in the vegetable kingdom.

EXPLANATION OF PLATES.

Plate XII.—Examples of Spicate Grasses.

Fig. 1. Unilateral spike (*Nardus stricta*).

2. Bilateral spike (*Brachypodium pennatum*).

3. Compact lanceolate spike (*Alopecurus pratensis*).

4. Oval spike (*Phalaris canariensis*).

N.B.—The letters refer to the names of parts in the "Analysis of a Grass," p. 188.

Plate XIII.—Examples of Paniculate Grasses.

Fig. 1. Upright panicle of *Bromus mollis*, var. *racemosus*.

1′. Glumel of ditto (½).

2. Ditto of *Aira caryophyllea*.

3. Diffuse panicle of *Briza minor*.*

3′. Enlarged locustæ of ditto.

4. Drooping panicle of *Poa nemoralis*.

N.B.—The letters refer to the names of parts in the "Analysis of a Grass," p. 188.

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* This drawing was made from a specimen most kindly communicated to me, with other rarities, by H. C. Watson Esq., of Thames, Ditton.

HISTORY OF THE REFLEX THEORY.

BY G. H. LEWES.

"IT is my conviction," says Professor Bennett, "that when the bitterness of personal opposition has subsided, the impartial world of science will award to Marshall Hall the honour of not only originating, but of establishing, and practically applying to the treatment of disease, one of the most important physiological doctrines discovered since the days of Harvey."* Several other testimonies to the like effect may be read in the same volume, which have induced me to write the history of the doctrine in question, not only with a view of assigning to Marshall Hall his real position, but also of adding a chapter to the history of our knowledge of the nervous system. As the estimate I have been able to form of Marshall Hall is by no means of that exalted kind which will constantly be met with in the pages of his Memoirs, it may not be wholly superfluous to state, that in no sense can "the bitterness of personal opposition" apply to me, since I never saw the distinguished physiologist, nor did I ever come into any personal relation with him, direct or indirect. I shall leave it to history to show that he did not originate the Reflex Theory, and that, so far from having "established one of the most important doctrines since that of Harvey," the doctrine has long been given up by every physiologist of repute in Europe; and that the Reflex Theory now generally established, positively rejects all that Marshall Hall claimed as his discovery.

What is the Reflex Theory? This is the first point to be settled. To state it briefly, we may say, that it is an attempt to describe the *mechanism* by which certain acts in the living body take place without consciousness; and to connect with this same mechanism, all those acts in decapitated or brainless animals which *look* like acts prompted by sensation and volition, but which *cannot* be so prompted—it is held—because sensation and volition are seated in the brain. If a man be in a state of complete unconsciousness, from the pressure of a bit of bone on his brain, so that he neither sees, hears, nor feels, this cessation of cerebral activity does not prevent his breathing, swallowing, &c. The chest expands, the œsophagus contracts on being stimulated, the heart beats, the intestines move,—these and numerous other nerve-actions go on nearly as well

* "Memoirs of Marshall Hall." By his Widow (p. 117).

without the brain as with it; and even when the brain is present, and uninjured, these actions mostly take place without exciting any sensation. How is this?

Aristotle, and the earlier physiologists, made short and easy work of it. According to them the soul moved the body, and every action was due to an impulse of the soul; *how* the motion was effected no one attempted to explain. As, however, it appeared that the mind was not conscious of some of these impulses, the hypothesis was formed of three different souls or three forms of the one soul (the rational, the sentient, and the vegetative), which severally presided over the functions of intelligence, volition, and nutrition. This hypothesis was deemed so satisfactory that it reigned undisturbed until the middle of the seventeenth century. To the modern physiologist, it seems nothing but a re-statement of the original difficulty: it gives a name to the cause of the phenomena of growth, volition, and intelligence, but in no sense does it explain the phenomena—in no sense does it unveil the cause. Indeed, the mechanism of nervous phenomena was scarcely suspected at this period.

Our own Willis was the first to sketch this mechanism. His exposition of the nervous system, in man and animals, made an epoch; and although his physiology is encumbered with "animal spirits," "subtle atoms," "flames," and other superstitions of his day, it is a great advance on what had previously been taught. The problem we have at present before us he solved by the hypothesis of two souls—one, the *anima*, or sensitive, corporeal, igneous soul of brutes, which presides over all the organic processes, as well as over all instincts, emotions, and involuntary acts; and another, the *animus*, or rational, immaterial, immortal soul, which is the exclusive appanage of man; the *anima* man shares with brutes, the *animus* is his peculiar prerogative. It would lead me too far to detail the anatomical mechanism which Willis has assigned for the functions of these souls, or his attempt to localize perception in the *corpora stricta*, imagination and appetite in the *corpus callosum*, and memory in the convolutions of the *cerebrum*;* enough for the present to indicate that he made the nervous system the *instrument* of the rational soul, and the *body*, so to speak, of the sensitive soul.

Stahl, less of an anatomist, and more of a metaphysician, admitted but one soul—the rational. To it he assigned all the actions of the body. As to the obvious objection that the soul was quite unconscious of many impulses necessary to organic life, he replied that this was quite consistent with his view. He

* See particularly *De Animâ Brutorum*, i. cap. iv. (*Opera*, ed. 1676, vol. ii. p. 36.)

profoundly saw that the mind does not always reflect upon its acts; some of its most indubitable acts are performed unconsciously.* This conception of the soul as tantamount to both mind and vital principle still finds ardent advocates; and this very year an eminent professor (Tissot) has published a thick volume ("La Vie dans l'Homme") which may be called an amplification of Stahl's hypothesis.

But we are seeking the organic *mechanism*, and these hypotheses will not assist us. The dawn of the discovery is in Unzer's celebrated work, which the "Sydenham Society" has made generally accessible, through Dr. Laycock's translation.† Unzer not only collected a mass of interesting facts relative to the actions of the nervous system, but discriminated them with great precision, and attempted to determine their mechanism. He classed all the phenomena under the two heads of sentient actions (*actiones animæ*), and nerve-actions—the latter being wholly *independent* of sensation.

It is true that the only proof of their being independent of sensation is that they may be seen in brainless animals; which, as I have elsewhere shown, is no proof at all.‡ "Thus," he says, "a decapitated animal will stand, move forwards, raise itself up, leap, fly, flutter its wings, seek food, clean, defend or conceal itself, &c. A decapitated man, immediately after decapitation, struggles to free his hands, attempts to stand upright, and to stamp with his feet. If the head of a pigeon be cut off whilst it is running, it continues to run on for some distance until it knocks against something; a frog leaps forward without its head; a snake, a fish, a worm, writhes and twists about, if touched, although wholly deprived of sensation; a fly makes a movement of brushing its eyes by a natural instinct, although its head be cut off; a headless snail seeks its food by its usual plan of feeling about; a decapitated tortoise does the same thing, and will live for half a year after decapitation, and raise itself up, or endeavour to do so, if placed on its back; an earwig nips with the nippers of his abdomen at its own separated head, when the head bites the abdomen; in short, all the instinctive actions of animals are sometimes seen to occur as nerve actions; and it naturally follows that they occur as such, at first in newly-born animals, and that it is only after the perception of external sensations that they become sentient actions." Here we perceive that the reason why these actions are excluded from sensation is because

* STAHL: *De Mechanismi et Organismi Diversitate.*

† UNZER: *The Principles of Physiology.* PROCHASKA: *A Dissertation on the Functions of the Nervous System.* Translated by Thomas Laycock, M.D.

‡ The Reflex Theory, and the evidence on which it is based, are fully discussed in the "Physiology of Common Life," vol. ii.

the perception of external sensations is removed by removal of the brain. Unzer thinks that the brain is the seat of the soul, and it is impossible for any other organ to have a sensation. Hence he remarks, "a headless tortoise lives several months; *it cannot possibly feel the sensation of faintness from an empty stomach;* yet the external impressions must change the vital movements contra-naturally like that painful sensation, because it becomes feeble and faint from starvation. The digestive organs must be excited to the movement, which are requisite to digestion, by the external impressions of emptiness, just as by the instinct, since the bowels are moved peristaltically and the digestive fluids are secreted."

Having thus proved, as he thinks, that many actions take place without sensation, because they take place without the brain, Unzer ascribes to a similar mechanism all those actions of which we are unconscious: in such cases the impressions on the sensitive nerve are not transmitted to the brain, but are *deflected* from their course, and excite the muscles, without having reached the brain. "What prevents the propagation to the brain?" he asks. "There is nothing to be found in the nerves adapted to this end, except certain formations found scattered on the nerves, termed ganglia." This conjecture may or may not be accepted, he says, "still the fact remains, that external impressions on certain nerves excite movements without reaching the brain and without being felt." Replace this hypothesis of the ganglia on the nerves, as the centres of deflection, by the hypothesis of the spinal centres, and the modern Reflex Theory is before you; not indeed the theory of Marshall Hall, but that of his successors.

Prochaska is the next name on our list. As far as my own investigations and meditations enable me to understand this complex subject, Prochaska seems most nearly to have approached to a philosophical and systematic explanation, however erroneous some of his details may be. He alone, since Stahl, has seen the necessity of making *all* the nervous centres seats of *sensation,* and the brain the seat of *ideation.** "However composite the machine of the nervous system may be," he says, "I think it may be divided into three portions, just as its functions are most conveniently ranged under three divisions; namely, in the first place, the animal organs (or the organs of the *mental* faculty), the cerebrum and cerebellum; secondly,

* Cæsalpinus held this view: "Ibi esse animæ principatum *ubi origo est nervorum;*" it is true that he, believing the heart to be that origin, immediately adds, "Sed hoc cerebrum esse, non dicet nisi is qui crassè hæc contempletur."—*Peripateticarum Quæstiones,* 1571, p. 108. Whytt had arrived at the conclusion that the whole, and not a part, of the nervous system, was the seat of the mind; but he placed reason in the brain and sensation in the nerves.—(*Works,* p. 288—note.)

the *general sensorium*, which appears to consist of the medulla spinalis, medulla oblongata, together with that portion of the cerebrum and cerebellum from which the nerves directly arise; and thirdly, the nerves themselves."

This luminous conception of the general *sensorium* being co-extensive with the origin of all the nerves, and not confined to the brain, or to some particular part of the brain, was unhappily not in harmony with the views then general. Had it been adopted, I cannot but think that we should now have been much further advanced than we are. Be this as it may, for the present we have to show its bearing on the Reflex Theory. "The external impressions," he says, "which are made on the sensory nerves, are quickly transmitted along the whole length of the nerves, as far as their origin,"—that is to say, as far as the spinal centre, or sensorium,—"and *having arrived there they are reflected by a certain law*, and pass on to certain corresponding motor nerves, through which, being very quickly transmitted to muscles, they excite certain definite motions." He adduces a number of examples,—sneezing, coughing, winking, convulsive movements of epilepsy, retraction of pricked limbs, and all the actions in decapitated animals; so that it was impossible for any one, conversant with his work, not to see that he had anticipated much of what Marshall Hall claimed to have discovered. Accordingly, the charge of plagiarism was raised against Marshall Hall, and much heartburning was excited. But, on this point, Hall is certainly blameless. It is true that Prochaska had explained reflex phenomena, had named them reflex, and had assigned the spinal chord with the sensory and motor nerves, as the mechanism by which they were effected. But, in the first place, Prochaska's views had fallen into utter neglect; and, in the next place, Marshall Hall's theory was, in some respects, different from that of Prochaska. So complete was the neglect, that when Marshall Hall declares he had never heard of these views, until his critics challenged his originality, we are bound to believe him; we are bound, by the general principle, that the word of an honourable man is not lightly to be doubted; and by the overwhelming presumption against the likelihood of his having seen Prochaska's work. His critic in the *British and Foreign Medical Review* asserted that if Hall's denial were true, such ignorance was "discreditable to him as a scholar;" he ought to have been acquainted "with so striking a work as that of the Professor of Prague." Now, as far as my researches extend, *no* eminent physiologist, English or German, had taken any notice of Prochaska's views. Rudolphi, one of the most eminent and erudite, does indeed include Prochaska's anatomical tract, *De Structura Nervorum*, (which has nothing to do with the reflex theory,) in his bibliography; but he mentions no other work, and makes no

allusion to Prochaska's opinions.* Gall mentions and cites Prochaska, but had evidently paid no attention to his physiological views, since he does not even allude to them.† Richerand and Majendie, the two leading physiologists of France, know not even Prochaska's name. Johannes Müller, the Haller of our day, had quite forgotten, if he had ever known anything of Prochaska; and, in yielding the priority to Marshall Hall, never suspected that a countryman of his own had already promulgated the theory. The erudite Dr. Thomson, in 1832, the very year before Hall announced his discovery, in his account of Continental physiologists who had advanced our knowledge of the nervous system, never mentions Prochaska.‡ Nay, even J. W. Arnold, writing after the theory had become European, in giving a sketch of Hall's predecessors, mentions Unzer, but says not a word about Prochaska.§

There can be but one conclusion from these facts: the work which such physiologists overlooked, we may readily suppose was unknown to Marshall Hall, especially in days when access to German works was incomparably more difficult than it is now. While I wholly acquit him of plagiarism, I cannot but think that he acted ungracefully in not recognizing Prochaska's priority when once it had been pointed out, the more so, as he might still have vindicated his own originality. There is manifest injustice in the common tendency to deprive a man of his claims to our gratitude by ransacking old archives in search of some phrase, or some forgotten theory, which reads like an anticipation. On this point one may say with Malpighi (who, by the way, is the original discoverer of many modern discoveries) that where a discovery has passed out of men's minds, and is as dead as if it had never been born, he who reproduces it is entitled to the reward of an inventor, "dicitur nova inventio illa, quæ licet fuerit cognita alicui præteritis seculis, nihilominus de ea apud posteros nulla extitit memoria, quia cum illa non pervenerit ad nostram cognitionem pro usa nostro, est tanquam nunquam extitisset."‖ Very often the anticipation is a mere phrase, a vague guess, or a suggestion not followed up; sometimes it is a real vision, but is so far in advance of the science of the day as to attract no notice and admit of no application. Nothing can be more evident than that Hooke and Mayow had very clearly and scientifically explained the phenomena of combustion and respiration; nevertheless, when Lavoisier and Priestley, by similar experiments, established similar theories, a century later, their fame was not diminished

* Rudolphi: *Grundriss der Physiologie*, ii. 1823.
† Gall et Spurzheim: *Anat. et Phys. du Système Nerveux.* 1810.
‡ Thomson: *Life of Cullen*, vol. i. 1832.
§ Arnold: *Die Lehre von der Reflex Function.* 1842.
‖ Malpighi: *Opera Posthuma*, 1697, p. 5.

by the priority of Hooke and Mayow. We may say the same of Prochaska and Marshall Hall. Had not Lavoisier and Priestley, or some one else, established their theories, no mention would have been made of Hooke and Mayow, except as curious experimenters. Had not Marshall Hall and Müller made the Reflex Theory a European doctrine, we should not have heard of Prochaska; for, as I have shown, the Reflex Theory had no existence among scientific doctrines; it had not attracted even the notoriety of a doctrine considered to be absurd.

During the half-century which elapsed between Prochaska and Marshall Hall, the subject was approached by another route, namely, the investigations into the spinal chord, which became gradually of great importance. It will surprise the student of our day, aware of the large place occupied in physiology and pathology by the phenomena assigned to the spinal chord, to see how little notice was taken of it only a few years ago. Two indications will suffice. Richerand's Physiology, which was long accounted as the first of text books, has no notice whatever of the spinal chord, in the edition published in 1807; and the work of Rudolphi, published in 1823, out of an entire volume given to the nervous system, devotes but one page to the spinal chord, and that is occupied with discrediting the ideas of Legallois, who made it a sensorial centre. Nevertheless, as I said, experimentalists were busy. In 1803, J. J. Sue advanced the hypothesis that the spinal chord was capable, to some extent, of replacing the functions of the brain.* In 1812, Legallois published his celebrated work,† wherein this idea of Sue's was developed and confirmed by very striking evidence, showing that, in the absence of the brain, the chord became a centre of sensation and volition; showing also that separate portions of the chord were separate centres, having separate bodily actions under their control. In 1817, Fray‡ declared the chord to be the organ which presided over all the internal economy, which during walking and sleeping regulated all the organic actions, and acted as their sensorial centre. In the same year, Wilson Philip § also maintained the sensorial character of the spinal chord. In 1822, Sir Gilbert Blane opposed this idea, and denied that the actions of decapitated animals, as well as the instinctive actions of sucking or breathing, were prompted by sensation. He held the brain to be the exclusive seat of sensation, and was consistent in his view that all instinctive and automatic actions were independent of sensation.‖

* Sue: *Recherches sur la Vitalité.*
† Legallois: *Expériences sur le Principe de la Vie.*
‡ Fray: *Essai sur l'Origine des Corps organisés et inorganisés.*
§ Wilson Philip: *Inquiries into the Laws of the Vital Functions.*
‖ Gilbert Blane: *Croonian Lecture in Select Dissertations.*

Thus the path was cleared for Marshall Hall. Ample evidence had been collected to prove that there were other centres of nervous action besides the brain; that the phenomena which depended on these centres were those actions usually styled instinctive and automatic, and those observed in decapitated animals; and that these centres were situated in the spinal chord and medulla oblongata. While some thought that these centres were sensorial, others said, No: they insisted on the brain only being capable of "sensation;" so that all acts which were not dependent on the brain, were said to be divorced from consciousness. In 1833 Marshall Hall first disclosed his theory, which was briefly this:—There is a distinct class of actions, called reflex actions, wholly independent of sensation or volition. These belong to a *distinct* nervous mechanism, "the true spinal system," with a *separate* set of nerves, the excitor and the motor nerves. An impression on the surface is conveyed by an *incident, excitor* nerve to the spinal centre, and, instead of being transmitted upwards to the brain, is immediately *reflected* along the *motor* nerve to the muscle.

On comparing this with Prochaska's statement, it will be seen that the only differences are in denying the presence of sensation, and in supposing the existence of a separate anatomical mechanism, "the true spinal system." The first of these differences is a matter of opinion on a point wholly incapable of proof, but in which the presumptive evidence is, I conceive, wholly against Marshall Hall. The second of these differences is an hypothesis, which Hall never attempted to prove anatomically (though his distinguished disciple, Mr. Grainger, attempted it for him), and which is universally *rejected* by all Europe.

Thus, although Marshall Hall has the credit of having revived (not originated) the Reflex Theory, and, by his more precise application of it to various physiological and pathological phenomena, has given it a new importance in the eyes of the scientific world, his claims as a "discoverer" are reduced to that of a systematizer. That which was *new* in his theory is now universally rejected as erroneous; that which was *true* in it was known to others. But he systematised and placed in a striking light what was confused and obscure; he made the Reflex Theory the doctrine of the schools. Such is the verdict which the impartial world of science will deliver; and if it is somewhat different from the verdict prophesied by Professor Bennett, it is quite in accordance with what a physiologist, greatly his superior, has delivered:—"The facts had been witnessed and reasoned upon by various physiologists," says Professor Sharpey, "but to Dr. Marshall Hall belongs the credit of having fully shown the connection with each other, of having first successfully generalized them, and of having given to this part of physiology the form of a consistent doctrine; and

to him belongs exclusively the merit of applying a knowledge of these phenomena to pathology." *

Even had Prochaska never lived, and as far as Hall is concerned we are bound to consider him as non-existent, the sole claim which can be made to a discovery is founded on the true spinal system, with its separate sets of nerves. That is Marshall Hall's own; and that is an error. All the rest belongs to others. That it does belong to others is seen in the fact that the Reflex Theory, divested of this hypothesis, was simultaneously promulgated, as a novelty, by Johannes Müller, who, on a comparison of dates, at once awarded to Hall the priority of publication. But Müller had no new facts to adduce; he simply generalized the known facts, respecting the action of the spinal chord; and connecting them with the assumption of the brain being the sole seat of sensation, he declared the independence of the spinal chord, and the absence of sensation in its special acts.

But while history thus irrefragably shows that Marshall Hall made no discovery at all, even if Prochaska's claims be set aside, and that it is therefore preposterous to compare him with Harvey, who revolutionized physiology, and *demonstrated* that which no one before him had suspected,—whereas Hall demonstrated nothing but what was already well known,—still I think that science was greatly benefited by the zeal, the energy, and the ability with which Marshall Hall worked out the Reflex Theory, and applied it to the explanation of many physiological and pathological facts. It is only necessary to compare the state of our knowledge now, with its condition when he first published, to see what an immense advance has been made, much of which is certainly due to the discussion of points raised by him. Even the hypothesis of a separate spinal system, erroneous as it was, proved of great service, like many other erroneous hypotheses: it gave a definite direction to research. And if his successors have bit by bit destroyed all that was peculiar in his statement of the Reflex Theory, extending and modifying the theory to suit the advance of knowledge, and leaving it much more like the theory advanced by Prochaska; we must nevertheless remember that it is owing to Hall's striking hypothesis, and more systematic arrangement of known facts, that successors, in a great measure, have been enabled to improve upon his theory.

To sum up, we may say, that if Marshall Hall was not a great man, he was a distinguished man, and has "deserved well of his country."

* SHARPEY, as quoted in Hall's *Memoirs*, p. 109. And compare, also, what MARSHALL HALL himself admitted in his first paper, presented to the Royal Society, p. 659, and in his *New Memoir*, p. 87.

SOLAR CHEMISTRY.

BY ROBERT HUNT, F.R.S.

"THE fable of Prometheus is but the outshadowing of a philosophic truth," was the language used by Lavoisier to express his belief in the direct dependence of all organization on influences derived from the Sun. Every advance which has been made in the examination of this most interesting subject, proves that *energies* originating in that vast globe, determine the phenomena of life on this earth, and regulate nearly all the conditions of the inorganic world.

Situated at the enormous distance of upwards of ninety-five millions of miles from us is this great orb, having a diameter of 882,000 miles, which forms the centre of the solar system. Not only is the Earth and each of the other planets chained to the Sun by the attractive power of its mass, but their motions are determined by its motion, and the physical forces which regulate all cosmical phenomena have their source within its body. The Sun, figuratively termed "the fountain of Light," is equally so, of every other Power with which science has made us acquainted. An infinite store of creative energies is amassed in the solar orb. These are diffused in obedience to the Creator's word, and flow for ever throughout the universe, to be absorbed by the planetary spheres, producing alike, the crystalline arrangement of rock masses, and the development of vital forms.

"Man," says Bacon, "is but the minister and interpreter of nature, and can neither extend his power nor his knowledge a hair's breadth beyond his experience and observation of the present order of things." Entirely acquiescing in this, we feel, nevertheless, that we have scarcely yet recognised the vast power of the human mind. Guided aright, man can penetrate the arcana of space, and dive into the tomb of time. With telescopic eye he can reach the worlds remote in space, and study the chemistry at work within them, while his microscopic vision enables him to detect the presence of the minutest monad, and watch the kindling of life's faintest spark. Although, as we have said, there are more than ninety-five millions of miles of space between this Earth and the Sun, the human mind has bridged the gulf, analysed the solar matter, and shown how, in all probability, the physical forces are developed. To explain this as clearly as possible is the purpose of the present paper.

Since the time when Newton analyzed the solar beam, the

advance of our knowledge has been rapid. We know of luminous rays which were never seen by that philosopher. Of the chemical action of light he was ignorant. The beautiful phenomena of the Polarization of Light were unknown to him, and of the existence of numerous *dark lines* crossing even the most brilliant divisions of the Newtonian spectrum—and which promise to advance our knowledge by the discovery of many sublime truths,—he had not the most remote idea. Yet, notwithstanding this want of the knowledge with which we are familiar, Newton possessing, in a remarkable degree, that power of thinking out a truth, which showed itself so strongly in the philosophers of Athens, proposed an hypothesis, which has been set aside and almost forgotten, but to which we are now returning, to adopt it as the most truthful theory of the physical condition of the Sun.

With the following quotation from Newton's "Optics," let us fairly introduce the inquiry, which, with every advance, appears to confirm his views:—

"May not great, dense, and fixed bodies, when heated beyond a certain degree, emit light so copiously,—as, by the emission and reaction of their light, and the reflections and refractions of their rays within their pores—to grow still hotter, till it comes to a certain period of heat, *such as is that of the Sun?*

"And, are not the Sun and fixed stars great earths, vehemently hot, whose heat is conserved by the greatness of the bodies, and the mutual action and reaction between them and the light which they emit?"—(*Newton's Optics.*)

Since Newton's days, this hypothesis for a considerable period was discarded, and more especially so, since Sir William Herschel gave to the world his investigations on the solar spots. The prevailing idea has been that the Sun is a dark mass; that floating above it there exists a stratum of opaque clouds; and that surrounding—enveloping—those is the *Photosphere,* or sphere of light, whence we derive the luminous powers on which vision and colour are dependent.

Arago and Biot determined, by a series of beautifully devised experiments, dependent on the phenomena of the polarization of light, and by careful observations, that the luminous principle, originating in the photosphere, is produced by a gaseous or vaporiform medium in a state of intense combustion. This discovery did not, however, interfere with the idea that the mass of the Sun was dark and cold. It is only within a very recent period that inquiries in a new direction have taught us to doubt the correctness of the views originating with the elder Herschel, and have led us back to the speculations of Newton.

To explain these modern investigations, it will be necessary to examine with some care the known conditions of the solar agencies, and some of the peculiar phenomena of Light.

If through a pin-hole made in a window-shutter a sunbeam is allowed to pass into a dark room, three phenomena are rendered evident to our senses. LIGHT, producing vision and developing colour, is shown upon every particle of dust floating in the luminous pencil. HEAT is sensibly felt, if the hand is placed in the path of the ray; and ACTINISM, or *chemical power*, is rendered evident by the change produced, if we allow the beam to fall on any photographic preparation. That the sunbeam should have the power of breaking up the strongest combinations depending on chemical affinity, is one of the wonderful discoveries of science. Now, if we place a triangular prism of glass in the path of the sunbeam, the rays are bent out of their course, or refracted, and by this means decomposed into a beautiful flame-like chromatic image. If this solar spectrum—this section of a rainbow—is received upon a screen, it will be found to consist of several coloured bands; crimson, red, and orange passing into yellow from the least refracted end, while from the most refrangible one, we have lavender, violet, indigo, blue, and green, also passing into yellow, as they advance to the true centre of the spectral image.

These rays constitute the Newtonian spectrum; so-called from Newton's having first examined, with precision, the relative conditions of these coloured bands, and established, with any approach to correctness, the laws regulating the relations of colour and refraction.

Beyond the most refrangible end of this spectrum there exists another class of rays, which are not visible under ordinary circumstances. If, however, the rays of Light are intercepted by solutions of sulphate of quinine, or of horse-chestnut bark,—by a block of canary-yellow glass, coloured with the oxide of uranium, or by a crystal of fluor spar, those extra spectral rays are rendered apparent. Those rays, which were unknown to Newton, have been investigated by Professor Stokes, who has named them the *Fluorescent rays*. They are luminous, probably under all circumstances, to those animals whose eyes are adjusted—as the eyes of most of the night-roaming creatures are—to admit the rays of highest refrangibility, and to vibrate in unison with their vibrations; but, unless peculiar conditions are established, the fluorescent rays are not sensible to the human eye.

Such, then, is the amount of our knowledge respecting the luminous principle of the sunbeam. It must not be forgotten that the rays of which we have been speaking vary considerably in the intensity of their illuminating power. The maximum

exists in the Yellow ray, and it diminishes as we recede from it towards either end of the spectrum. The least refrangible, or the Red rays, give a modified amount of Light; but the maximum of Heat exists in them. The most refrangible, or Blue end of the spectrum, is less luminous; but the maximum of chemical action is fixed at this extremity, the fluorescent rays beyond the spectrum of Newton being visible only under the peculiar circumstances mentioned.

When these beautifully coloured bands of Light are well defined upon a screen, let the inquiring reader examine the image with a small telescope. A new set of phenomena will become apparent. The spectrum is then seen to be crossed by a vast number of *black lines*. Every ray, even the most brilliant, will be seen to have spaces in which there is an entire absence of light. To these we would now direct attention.

It is instructive to trace the steps by which we slowly advance to the discovery of a great truth. As in ascending a tall column, the way may, for a season, prove dark and possibly —being without promise—wearying; but, eventually, the gleams of light are seen, and presently a wide horizon is opened to our view. Thus has it been with this inquiry.

Dr. Wollaston was the first who observed the existence of non-luminous spaces in the prismatic spectrum. Dr. Ritchie proved that these lines were dependent on absorption, and showed how they could be *increased in visible numbers by artificial means*. Fraunhöfer, however, was the first to make a full investigation of these lines, and to publish a map of them; hence they have been generally called Fraunhöfer's lines.

These lines are of so fixed a character in relation to the coloured bands of the spectrum, that if it is desired to indicate with great precision any special ray of the spectrum, we refer to them by their letters or numbers. In the accompanying plate, the more remarkable lines only are given. The positions they occupy have been determined, by a careful examination of the map of Fraunhöfer, and the very complete delineation of those lines published in the "Philosophical Transactions for 1859," by Sir David Brewster and Dr. Gladstone. Fraunhöfer laid down on his map 354 lines, but Sir David Brewster says—"In the delineations which I have executed, the spectrum is divided into more than 2,000 visible and easily recognized portions, separated from each other by lines more or less marked."

The lines marked with capitals from A to I in the plate may be always easily detected in any Solar spectrum. Those which are indicated by small letters, and those which are numbered, are the more marked lines observable in Sir D. Brewster's map; the letters and numbers agreeing with those which he employs.

The origin of the dark lines—spaces in which there is no Light—can scarcely be said to be yet resolved. Fraunhöfer, and

others following him, thought that the Light emitted from the photosphere was, from the first, deficient in those rays, or that they were lost, either by absorption in passing through the solar atmosphere, or possibly in passing through that of the Earth. Angstrom,—who also discovered many *bright lines* in the spectra from artificial lights,—advanced some highly philosophical views in 1855; but the investigations of Bunsen and Kirchoff, remarkable alike for the delicacy and caution observed in the inquiry, and for the refined nature of their deductions, lead us probably up to the true explanation of these phenomena. The dark lines of the Solar Spectrum, and the bright ones observable in the spectra obtained from artificial lights, have been investigated by Professor Wheatstone, Dr. W. A. Miller, Mr. Fox Talbot, and Sir John Herschel. These investigators have proved that the spectra obtained from the Light emitted from incandescent mineral bodies differ from that obtained from the Sun; that the lines from artificial sources of Light are, in many cases, peculiar; and that, in the majority of instances, *bright lines* appear to take their place. So rigidly exact were the positions and characters of the lines obtained from differently coloured flames, that both Wheatstone and Miller suggested the adoption of spectral or prismatic analysis, as a means of determining the presence of exceedingly minute quantities of any substance. The investigations of Bunsen and Kirchoff have, from their high interest, again drawn attention to this subject. These lines, *dark* and *bright*, have been employed in the analysis of the solid mass of the Sun itself; and the extreme delicacy of the indications is proved from the discovery, by Bunsen, of two new metallic bodies—one called *cæsium* (meaning bluish gray), and the other *rubidium* (from the Latin *rubidus*, which was used to express the darkest red-colour), which existed in infinitesimally small quantities in some mineral waters of Germany.

By the beauty of the new phenomena observed, and by the boldness of the deductions drawn from the experiments made, the greatest additional interest has been added to this class of investigations. The discoveries, it must not be forgotten, have been arrived at by a series of steps, every one of them of the utmost importance, and it cannot but be regretted, that the most recent investigators have exhibited a singular blindness to the labours of other men. In the history of science, this will not redound to the honour of those in every way eminent philosophers, who unfortunately have not been able to rise above the little jealousies of ordinary mortals.

To render the phenomena, and the hypothesis involved, intelligible to those who may not have studied the subject, it is necessary to recapitulate, and enter a little into detail.

The image produced by decomposing a white sunbeam consists of certain brilliantly-coloured rays, but those rays are crossed by spaces giving no Light. The dark lines are always found in the same places in the solar spectrum, but they vary in number under different aspects of the Sun and varying conditions of the Earth's atmosphere. When the Sun shines in its meridian splendour from a clear sky, the number of dark lines is slightly different from those observed when the Sun, being near the horizon, has to penetrate a greater depth of atmosphere. "It is," says Dr. Gladstone, "a most beautiful and striking sight to observe the gradual appearance of these characteristic lines as the Sun descends towards the horizon," proving that some of these non-luminous spaces are due to terrestrial atmospheric absorptions. To quote again the same authority, "That the Earth's atmosphere has much to do with the manifestations of those lines, is beyond all question, and the analogy" (alluding to some very striking experiments made by Dr. Miller) "of such gases as nitrous acid or bromine vapour, *suggests the idea that they may originate wholly in the air that encircles our globe.*"

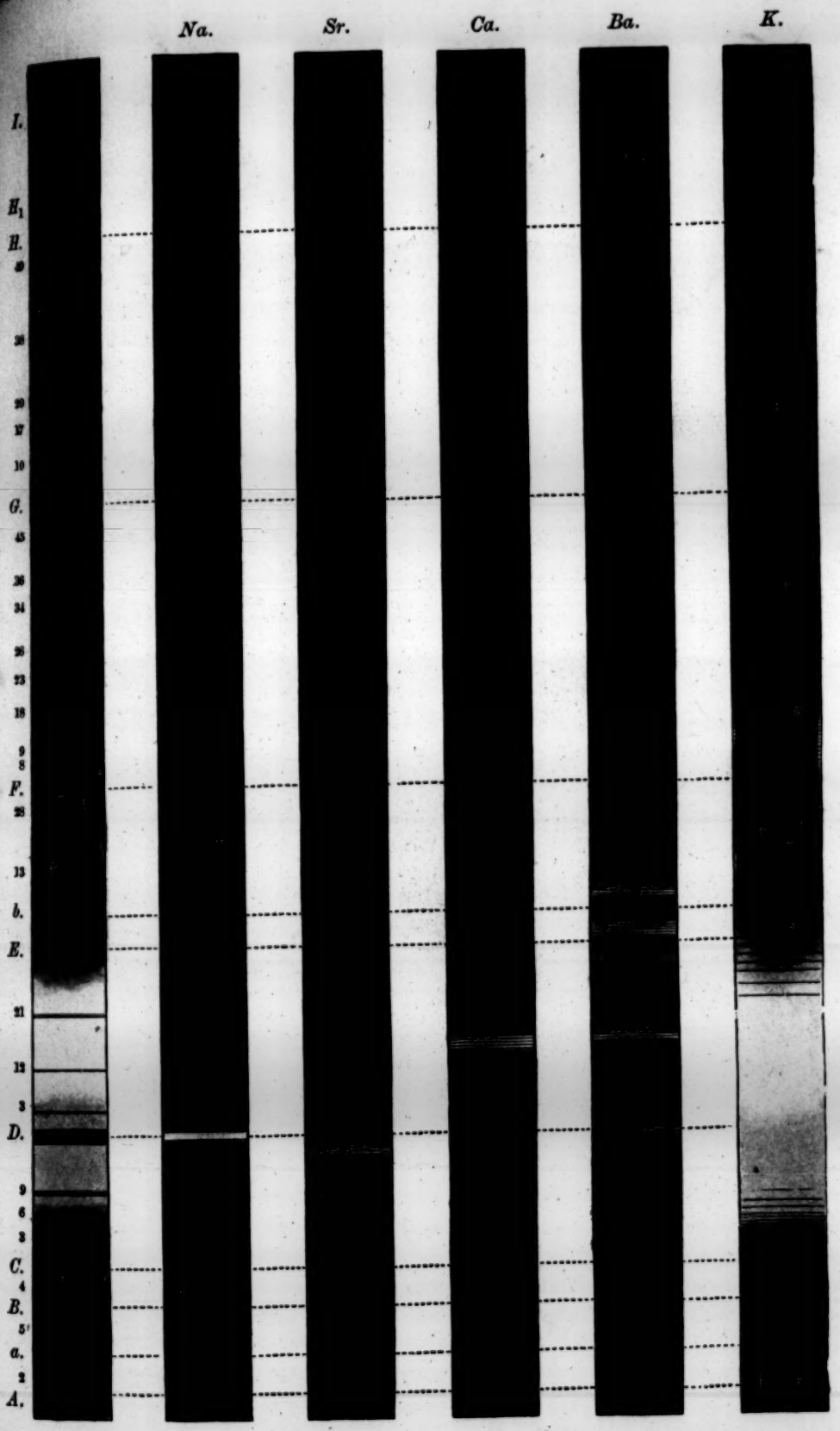
This suggestion is italicised for the purpose of giving our readers the full force of the evidence in favour of the views that the majority of those lines are of solar and not of terrestrial origin.

The spectra, obtained from some artificial sources of Light, exhibit the coloured rays shading one into the other; while those produced by some others, consist of a series of *luminous bands*, separated by dark spaces; and *these luminous bands are frequently found to coincide with the dark lines of the solar spectrum.*

Dr. W. A. Miller observed, that an intense yellow ray observable in the spectra, obtained from the flames coloured with soda, lime, strontia, baryta, zinc, iron, and platinum,—and, according to Angstrom, in the electric light of *every metal burnt* by him,—had the same refrangibility as the line D in the solar spectrum.

"But the most remarkable case occurs when carbon or sulphur is burnt in nitre. The brilliant Light, when analysed by a prism, exhibits a spectrum about as long as that of the sun at noon-day, but marked by *bright lines*, among which three are particularly prominent, respectively violet, yellow, and red in colour. The violet ray is not quite so refrangible as the solar H; but the yellow is coincident with D, and the red with A; while between the red and yellow appear at times fainter lines, one of which coincides with B, and a bundle sometimes appears in about the position of A."—(*Brewster and Gladstone.*)

Pyrotechnic displays will have made the least scientific of our


Na.
Sr.
Ca.
Ba.
K.
I.
H1
H.
49
38
30
27
10
G.
45
36
34
26
23
18
9
8
F.
28
13
b.
E.
21
12
3
D.
9
6
3
C.
4
B.
5
a.
2
A.

readers acquainted with the fact, that we may, by burning certain mineral substances, produce very intensely coloured lights. Soda, or common culinary salt, gives a monochromatic yellow; strontian produces the red fires of our theatres; barytes, the pale green of ghost scenes: copper burns with a green flame; iron, with a yellow-brown one; and lithium with a brilliant crimson. Now, if these flames be examined through a prism, or if a concentrated pencil from those artificial sources of coloured light be passed through one, we obtain well-marked spectral images, some of which are represented on the accompanying drawing.

1 is the Solar spectrum, with its principal black lines, those marked with capitals being the more important.

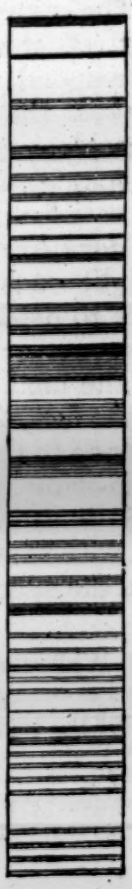
2. (*Na.*) The bright yellow line produced whenever soda, in any form, is present in the source of light.

3. (*Sr.*) The interesting series of bands produced by strontian.

4. (*Ca.*) The spectrum obtained when chloride of calcium, or any of the salts of lime, are subjected to combustion.

5. (*Ba.*) The spectrum produced by the barytes salts.

6. (*K.*) The spectrum observable when potassium or any of the salts of potash are vaporized in a flame.



The woodcut annexed, shows the extension of the solar spectrum to the end of the fluorescent rays. This is given to prove on the authority of Professor Stokes, that these most highly refracted rays have a larger number of *inactive* dark spaces than the more decidedly luminous rays possess. We have yet to examine, with the closest care, the relation of those lines to our own atmospheric influences. It is necessary, therefore, to observe much caution in receiving the evidence which has been brought forward in proof of the solar origin of those strange bands. But let us examine the proofs.

Kirchoff and Bunsen lay great stress upon the sodium spectrum, as proving the extreme delicacy of this mode of analysis. The yellow line—the only one seen—is coincident with the dark line D of Fraunhöfer. This beautiful bright yellow line is observable when less than $\frac{1}{20,000,000}$th of a part of soda smoke is mixed with air. From the circumstance of the air of these islands, having almost always some saline matter floating in it, the yellow line of the sodium spectrum is rarely absent. The lithium spectrum has not been represented on our plate; but it gives two sharply defined lines: one a bright red, the other a yellow one—the former apparently corresponding with line five between B

and C of Brewster's spectrum; it is not easy to determine accurately with which of the dark lines this yellow line is coincident.

Strontian gives six red, one orange, and one blue line. Calcium and its salts, a bright green line, an intensely bright orange line, and the paler intermediate bands. Barium gives well-defined green lines, some yellow lines, varying in intensity, an orange line, and indications of red.

Such are the general characteristics of the spectral images produced. Kirchoff and Bunsen say, in arguing upon these lines, and the hypothesis of their representing the solar dark lines: "It was proved from theoretical considerations, that the spectrum of an incandescent gas becomes *reversed* (that is, that the bright ones become changed into dark ones) when a source of light of sufficient intensity, giving a continuous spectrum, is placed behind the luminous gas. From this we may conclude that *the solar spectrum, with its dark lines, is nothing else than the reverse of the spectrum, which the sun's atmosphere alone would produce.* Hence in order to effect the chemical analysis of the solar atmosphere, all that we require is to discover those substances which, when brought into the flame, produce bright lines coinciding with the dark ones of the solar spectrum."

The coincidence of the soda line with dark line D is striking; one of the yellow lines produced by barium appears to correspond with it, and it must not be forgotten that Angstrom proved the yellow lines produced by other bodies to be coincident with D.* The red line of the potassium spectrum is coincident with the dark space A. The other lines are not so satisfactorily determined: where there are such a number of *dark lines,* there is no difficulty in assigning to one of the bright ones a place amongst them; but it requires the utmost care to determine the *exact* coincidence of a bright with a dark space.

The next step in the process of the investigation instructs us in the fact, that the vapours producing those coloured flames are opaque to their own rays. That is to say, if we produce a yellow soda-flame, and from it obtain a spectrum showing the peculiar soda lines in their bright yellow colour, and then impregnate the air with some soda vapour, by volatilizing soda between the flame and the spectrum, the *bright yellow line* becomes at once *a black*

* While those pages have been passing through the press, a communication has been made to the Parisian Journal (*The Cosmos*), by M. Morren, urging the necessity of caution in making deductions, because, as stated in this paper, the yellow line produced by Sodium is equally producible by other bodies. Professor Frankland and Dr. Tyndall, in the *Philosophical Magazine* for December, call attention to the influences of variation of temperature in altering the character of some of the lines.

line. This holds true for all the substances which have yet been examined. The coloured bright lines are converted into dark lines, if the rays from the coloured flames are made to permeate vapours of the same constitution as those which produced the particular spectrum under examination.

Incandescent gases and vapours give off Light of certain definite degree of refrangibility, or they furnish spectra consisting of certain fixed lines; and those incandescent gases or vapours absorb Light of the same degree of refrangibility as that which they emit. This is only the expression in relation to *Light* of the celebrated statement made in regard to *Sound—that a body absorbs all the oscillations which it can propagate.*

All the bright lines of the spectra produced by the vapours of known metals which have yet been examined appear to be represented by the dark lines of the solar spectrum. Angstrom says, "The analogy between the two spectra, the metal and the solar, may be more or less complete when we consider the details. When taken together, they produce the impression of one being the reverse of the other. I am therefore convinced that the cause of the lines of the solar spectrum involves that of the bright electric lines."

It is difficult, within a limited space, to express, in terms which shall be intelligible to those who have had no previous acquaintance with the subject, the evidences which support the views of Kirchoff as respects the Sun. If we have been successful in our description of the phenomena involved in the consideration of this subject, it will be understood that all the *bright lines* which are seen when we produce spectra from the coloured flames obtained by burning any of the metals, correspond with the *black lines* of the solar spectrum. That is to say, dark lines always existing in the solar spectral image correspond with every line produced by a spectrum obtained by burning Iron; and so with regard to the other metals which have been examined.

The conclusion, therefore, is that the radiations from the centre of our system,—the Sun,—producing the phenomena of *Light*, *Heat*, and *Actinism*,—are due to the combustion of metallic bodies such as we find on this Earth.

The mass of the sun is, according to this hypothesis, regarded as being intensely incandescent. Matter, in all respects, probably, similar to that with which we are acquainted, is undergoing combustion, and, of course, surrounding the sun with a vaporiform atmosphere, consisting of the emanations from the ignited nucleus. But for this atmosphere (or, to employ a better term, this *photosphere*), the solar spectrum would give a series of brilliantly-coloured *bright bands*. We have stated that vapours are opaque to their own class of rays:

therefore, since the rays produced by burning iron, or magnesium, or lithium, or other metals, are not transmitted through the vapours produced by the combustion of those metals, the solar spectrum gives us an extensive series of dark bands.

That *every* black line in the solar spectrum represents rays emitted from some metallic body in a state of combustion in the Sun, is exceedingly doubtful. It has been already shown that many of the dark lines are due to the want of absolute transparency in our own atmosphere. But that Kirchoff's view of the coincidence of the black lines of the solar spectrum with the bright lines of terrestrial flames is a fair deduction from his experimental observations, must be admitted.

At the same time as those inquiries by Kirchoff, Bunsen, and others, have been proceeding, investigations in another part have brought us corroborative evidence. The band of astronomical observers who went to Spain, to note with all accuracy the phenomena which might present themselves during the solar eclipse, bring us back evidence of tongues of flame, or clouds glowing with the reflected lights of an intense combustion, coming strongly into view, when the bright light was obscured by the moon's body. Professor Airy states it as his belief *that the sun is boiling up*, and that the prominences observed *were fumes given off*.*

The photographs of Mr. Warren De la Rue are invaluable as affording indisputable evidence of the existence of these "pillars of fire." Recently, that gentleman has brought his excellent appliances to bear on the unobscured Orb of Light, and his photographs confirm all the observations of Mr. Nasmyth. The Sun's disc is covered by masses of curiously shaped and ever-moving forms, called by their discoverer (Mr. Nasmyth) "Willow-leaves." The inference is, that these are tongues of flame ever bursting from this incomprehensible mass, and dispersing Light, and its attendant forces, to all the planets. We advance, by the aid of optical science, of chemical experiment, and astronomical observation, to the deductions:—That the Sun is constituted of matter similar to that which we find in this world: That this matter is ever burning; but, as Newton supposed, returning in a changed form into itself by the force of attraction in the mass: That the physical forces which are developed by those vast chemical changes are radiated in waves through space.

In conclusion, that man should, by the power of mind, be enabled to extend his investigations from the Earth to the Sun, and determine the chemical composition of a body, millions of

* Full details of this interesting phenomenon will be published in our next number, in an astronomical article, by Mr. James Breen, one of the observers referred to.—ED.

miles distant from him, is not a little remarkable, and proves the Divine origin of his intelligence; but, by his Philosophy, he has done yet more than this, in proving the completeness of the Balance of Forces throughout the universe. Vast chemical changes are taking place in the Sun, and, for every grain of matter altering its form, an equivalent of physical force is given out in a radiant state. These rays pass through space, and reach our Earth, and here they are employed in producing exact equivalents of vital and other phenomena.

The minutest terrestrial organism is the result of chemical changes taking place in the Sun. That stupendous orb is the great laboratory in which are generated those Powers by whose agencies all the planets of the system are regulated. In obedience to the Great Creator, who "caused the day spring to know his place,"—those mysterious agencies,—with the source of which man is now becoming acquainted,—are flooded out in profusion from the Sun, causing crude matter to pulsate into Life and Beauty upon every rolling orb within the solar realm.

THE OPTICAL PHENOMENA OF THE ATMOSPHERE.

BY G. F. CHAMBERS.

THOSE appearances in the heavens, such as the Rainbow, the Aurora, &c., which frequently present themselves to the gaze of man, although perhaps only for a brief space of time; and which, during that time surprise him by their brilliancy and beauty, were amongst the first external phenomena in nature that impressed themselves upon his dawning intelligence.

And yet, as we often find to be the case, those very common-place phenomena, which have been witnessed from time immemorial, are less understood than are the less striking ones, which, from the rarity of their occurrence, rivet the attention and lead to various speculations as to their nature.

It is our intention in the present paper to say a few words concerning these ordinary optical phenomena.

The *Rainbow* is one of the prettiest, as it is also one of the commonest atmospheric appearances with which we are acquainted: it is never seen but in showery weather, when the Sun illuminates the falling rain, and the spectator turns his back to the Sun, whose elevation above the horizon must not exceed 42°.

The earliest historic mention of the Rainbow is in Genesis ix. 13, where it is mentioned in connection with a pledge from the Great Ruler of the Universe that this Earth should never again be overwhelmed with another general deluge.

Homer says—

> "Like unto rainbows, which the son of Saturn
> Hath fixed in a cloud, a sign to articulate speaking men."*

Virgil speaks of Venus as—

> "The Virgin goddess, seen by none, hastening her journey through
> A bow of a thousand colours, glides down with a nimble tread."†

Various speculations are to be found in the works of old

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* *Iliad*, lib. xi. line 28. †*Æneid*, lib. v. line 609.

writers relative to the cause of the Rainbow; many of them seem to have had an idea, that the refraction of the Sun's rays had something to do with it, but in what manner they do not appear to have known.

There are frequently two bows seen—a primary and a secondary one: the former is by far the brightest, being formed by the rays of Light falling on the upper part of the drops of rain; for a ray of Light entering the upper part of a drop of rain will, by refraction, be thrown upon the inner part of the spherical surface of that drop, where, undergoing a second refraction, it will be sent towards the eye of the spectator; since the rays which fall upon the primary bow come to the eye after two refractions and one reflection, and the colours of this bow, reckoning *outwards*, are violet, indigo, blue, green, yellow, orange, and red. The secondary bow is formed by the rays of Light falling on the lower parts of the drops of rain: these rays, like the former, undergo two refractions; viz., when entering the drops of rain, and when emerging from them in passing to the eye; but they suffer two or more reflections in the interior surface of the drops: hence the colours of these rays are not so strong and well-defined as those in the primary bow, and appear in an inverted order: red first, then orange, &c. This may be experimentally shown in the following manner:—Take a glass globe, filled with water, place it in the sunshine, turn your back to the Sun and view the globe, at such a distance that the part of it farthest from the Sun may appear of a full red colour; then the rays which come from the globe will be found to make an angle of 42°, with the direct rays of the Sun: retain the eye in this position, and let another person gradually lower the globe; then the red, orange, yellow, &c. colours will appear in succession, as in the primary bow. Again, if the glass globe be elevated, so that the side *nearest* the Sun may appear red, then the rays which come from the globe will be found to make an angle of about 50° with the direct rays of the Sun: retain the eye in this position, and let another person gradually raise the globe; then the rays will successively change from red to orange, green, &c., as in the secondary bow.*

The breadth of a primary bow is about 1° 45′, and of a secondary one, 3° 10′. From theory we may be led to infer the existence of tertiary and quaternary bows, but owing to their position and faintness, they are usually invisible. In addition to the regular bows, supernumerary ones are occasionally seen, which depend for their development on certain peculiar conditions of the atmosphere. Lunar Rainbows may also be

* This illustration is, we believe, due to Keith.

seen under favourable circumstances, but they are somewhat rare.

Coronæ are meteors seen around the Moon and other heavenly bodies, and are of a whitish, nebulous character. Coronæ appear in cumuli clouds, are only visible when there is much moisture in the atmosphere, and generally foretell a change of weather. They are due to the diffraction of Light.

Halos are prismatic rings of variable but considerable diameter, seen around the Sun and Moon, with the red colour nearer the centre than the blue. Several very fine ones were seen in the month of January, 1860. They are caused by the refraction of Light; not unfrequently several rings may be seen concentric with one another. Humboldt describes a very fine lunar halo seen by him at Cumana.

Glorias or *Anthelia* are coloured circles surrounding the shadows of observers. M. Bougues mentions that when he, Don Antonia Ulloa, and his companions, were upon the summit of Mount Pichincha, one of the Andes chain, and the Sun just rising behind them, each saw his own shadow distinctly projected with a gloria surrounding the head. The anthelia consisted of three concentric circles of a lively colour and prismatic, the red being external.

Parhelia, or *Mock Suns*, are among the most beautiful of the meteors with which we are acquainted. They consist of halos and luminous arcs, intersecting one another in different directions and studded with solar images. These phenomena are also due to the action of atmospheric moisture on rays of Light, and are seen in the greatest perfection in the Polar regions.*

Paraselenæ, or *Mock Moons*, are not uncommon; they resemble in general character the preceding, and doubtless owe their origin to the same physical cause. Mr. E. J. Lowe, of the Beeston Observatory, thus describes a very remarkable halo with paraselenæ seen by him on November 12, 1859:—

"It consisted of a beautiful lunar corona, 10° in width, which exhibited faintly the prismatic colours. Also an ordinary bright halo, or circle of 22° 30′ radius, having the Moon for its centre; and a second very perfect circle, far too gigantic to allow of its being all seen at once, and therefore in the N.W. giving the appearance of an inverted rainbow. This circle had its centre 17° N.W. of the zenith, while its southern edge passed through the Moon. It was exactly 90° in diameter, yet gave the impression of being much larger. There were also seven mock moons. Two were situated at the intersections of the two circles; two others on the Moon's horizontal level and just without the circle of 22½° radius; the fifth and sixth on the great circle at a distance of 50° from the Moon on either

* See Parry: *Journ. of Voy.* 1819-20, pp. 156, 164, 172.

side; and the seventh on the same circle, a short distance without the smaller circle on the N. side. A lunar halo, and a small portion of the great circle, were seen for a short time by my assistant at 7 o'clock.

"This phenomenon was formed in cirri, and owed its disappearance to these clouds becoming cirrocumuli. The temperature was 32·2°, and the wet bulb thermometer 30·8°. The wind, a gentle breeze from E., the clouds floating in a S.W. current. At 12 30 a.m. (13th) the wind veered through N. to N.W."*

The Aurora Borealis is a luminous phenomenon seen in high latitudes in both hemispheres, and would with more propriety be termed the *Aurora Polaris*. It is, however, more commonly spoken of as the Aurora *Borealis*, or *Australis*, according to which hemisphere is referred to. The appearances presented, consist of streaks or rays of Light, of greater or less intensity, diverging in every direction from a central point, and which became visible in the northern horizon soon after sunset. Frequently a dull confused mass of Light, of a pinkish hue, appears, and it is from this that the phenomenon derives its name.†

The precise physical cause of the Aurora Borealis is not yet satisfactorily ascertained, but all the appearances connected with it are electrical; and its form, direction, and position, though ever varying, always bear a marked relation to the Magnetic meridian and poles. Whatever, therefore, be its physical nature, it is evident that the theatre of its action is the atmosphere, and that the agent to which the development is due is Electricity, associated, in some unascertained manner, with Terrestrial Magnetism. During the prevalence of Auroral displays, Magnetic needles are very generally subject to much disturbance—a fact first noticed by Halley. A copious deposition of dew, sudden thaws, and severe gales in the English channel, are also among the occurrences which seem to be connected with the appearance of this interesting phenomenon. Increased brilliancy in the light of the stars situated in the vicinity of the display has also been noticed. If the reader should be in possession of an electrical machine, he may obtain a very satisfactory representation of the Aurora by discharging an intermittent supply of electricity through a partially exhausted glass tube bent into the form of a semi-circle.

The Aurora Borealis seems subject to periodical visitations; sometimes it is seen very frequently, at other times years pass by without any apparitions being noticed. Thus we find that few were noted in the seventeenth century; at the beginning of the eighteenth, they recommenced, and lasted till about the middle of that century, when there was a partial cessation. During the last few years, as is well known, some splendid

* Letter in *The Times*, November 15, 1859.

† Aurora, the dawn.

displays have been witnessed, especially in 1859. Besides this secular variation, there seems to be also a mensual variation. The following table, derived from a large number of recorded displays, will illustrate this point:—

	PER CENT.
January	7·0
February	9·4
March	13·4
April	9·6
May	5·7
June	2·0
July	2·7
August	6·7
September	12·4
October	15·4
November	8·8
December	6·9
	100·0

Referring the above results to the four quarters of the year, we get the following table. The paucity of Auroræ during the summer months is doubtless partially to be ascribed to the shortness of the nights:—

	PER CENT.
Spring (March, April, May)	28·8
Summer (June, July, August)	11·4
Autumn (September, October, November)	36·5
Winter (December, January, February)	23·3
	100·0

There seems also to be a diurnal periodicity. Bravais remarks that auroral displays happen most frequently about 10 P.M., and rarely after 4 A.M.

Many observers have thought that they have heard sounds emitted by Auroræ. Possibly this is referred to by Virgil, who, after describing the prodigies at Cæsar's death, says:—

> "Armorum sonitum toto Germania cœlo
> Audiit."*

Much uncertainty exists on this point, as the evidence is very conflicting.

The influence of the Aurora in producing gales of wind seems to have been first pointed out by one John Winn, in a letter to Dr. Franklin, dated Spithead, August 12, 1772. He says:—

"I believe the observation is new that the Aurora Borealis is constantly succeeded by hard southerly or south-west winds,

* *Georgics*, lib. i. line 473.

attended with hazy weather and small rain: I think I am warranted, from experience, to say, constantly; for, in twenty-three instances that have occurred since I first made the observation, it has invariably obtained.

"Sailing down the English Channel, in 1769, a few days before the autumnal equinox, we had a remarkably bright and vivid Aurora the whole night. In-shore, the wind was fluctuating between N.N.W. and N.W.; and farther out, W.N.W. Desirous of benefiting by the land wind, and also of taking advantage of an earlier ebb tide, I dispensed with the good old marine adage, never to approach too near a weather-shore, lest it should prove a lee-shore; and by short tacks clung close along the English coast. Next day the wind veered to the S.W., and soon after S.S.W., and sometimes S. We were then in that dangerous bay between Portland and the Start Point, and carried a pressing sail, with hopes of reaching Torbay before dark; but night fell upon us with thick haze and small rain, insomuch that we could not have seen the land the distance of a ship's length. The gale now increased to a storm; nothing remained but to endeavour to keep off the shore till the wind should change. Luckily our ship was a stout one, and well rigged.

"Since I have made this observation, I have got out of the Channel, when other men as alert and in faster ships, but unapprised of this circumstance, have not only been driven back, but with difficulty escaped shipwreck."*

Colonel Capper remarks:—

"As it appears that on all such occasions the current of air comes in a direction diametrically opposite to that where the meteor appears, it seems probable that the Aurora Borealis is caused by the ascent of a considerable quantity of electric fluid in the superior regions of the atmosphere to the N. and N.E., where, consequently, it causes a body of air near the earth to ascend, when another current of air will rush from the opposite point to fill up the vacuum, and thus may produce the southerly gales which succeed to the Aurora Borealis, &c."

The earliest notice we possess of the Aurora is to be found in the writings of Aristotle. Other classical writers also allude to it. In 1574, in the reign of Queen Elizabeth, there was a fine display seen in this country, which Stow thus describes:—

"The fourtænth of Nouember being Sunday, about midnight following, diuers strange impressions of fire and smoake were seene in the ayre, to proceede foorth of a black cloude in the North towards the South, which so continued til the next morning that it was daylight. The next night following, the heauens from all parts did seeme to burne marueilous

* *Phil. Trans.* vol. lxiv. p. 128. 1774.

ragingly, and ouer our heads the flames from the horizon round about rising did meete, and there double and rolle one in another, as if it had bene a cleare furnace."*

In 1575, the Aurora Borealis was seen in Holland, and Cornelius Gemma, of the University of Louvaine, says:—

"The form of the chasma of September 28 following, immediately after sunset, was, indeed, less dreadful, but still more confused and various [than a previous display which occurred in the same year], for in it was seen a great many bright arches, out of which gradually issued spears, cities, with towns and men in battle array; after that there were excursions of rays every way; waves of clouds, and battles mutually pursued and fled, and wheeling round in a surprising manner."

There is strong reason to believe that the Aurora has become much commoner in Europe than it formerly used to be, and has correspondingly diminished in the northern parts of Asia, as Von Wrangel was informed by the natives. The Shetlanders speak of the Aurora as the "Merry-dancers." The ancients, amongst other appellations, called it the "Capra Saltans" (Dancing Goat). The wild Indian savage views in it the spirits of his forefathers roaming through the realms above. "Flying dragons, hostile armies, and other signs and prodigies, have been traced by the superstitious in the *bloody rods* and burning spears of the Aurora, no difficulty being found in accommodating the modes of celestial warfare to the ideas of the beholders and the times."

* *Annals.* Fol. London, 1631.

MISCELLANEA.

THE PROGRESS OF SCIENCE SCHOOLS AND CLASSES; WITH HINTS FOR THEIR FORMATION.

BY THE EDITOR.

TWO incidents have occurred since the publication of our last number, which exhibit in striking contrast the present condition of the two greatest nations on the globe. One of these events was of vast importance; it took the world by surprise, and was as eagerly canvassed by men of every rank and nation, as though it had been a defeat or victory which decided the fate of some great empire. The other was but of little moment in the political world; it barely served to interest for the hour, even during the inactivity of a parliamentary recess, and the report of its occurrence hardly extended beyond the sea-girt shores of Britain.

The first was the presentation, by the French Minister of Finance, of that memorable balance-sheet which showed the nation that, in consequence of its excessive expenditure for military and naval purposes, it was in debt forty millions of pounds beyond its income; whilst the second was nothing more than the visit to Liverpool of the English Chancellor of the Exchequer, in company with his noble colleague at the head of the Educational Department of the State, to inaugurate a new School of Science,—a public intimation that, notwithstanding the calls which had been made upon the Treasury to enable the nation, if need be, to cope with a bellicose ally, the Chancellor had in his coffers enough and to spare; and could afford any reasonable sum that might be required for diffusing useful information amongst the people.

If these two incidents afford any political lessons, they must be left to the consideration of statesmen, our business being only with the scientific and educational bearing of the one last referred to; and with this it is our intention to deal in the present paper.

The more we consider that great movement, of which the mainspring is the Science and Art Department of the Committee of Council on Education, and which is so young that it has not yet received a name—that national movement in science,—the more completely are we convinced that it is one which will add greatly to the welfare and happiness of our fellow-countrymen, and that it will be the means of affording remunerative as well as elevating employment to men and women in every class of society.

Our last brief article on the subject called forth inquiries from which we feel assured that if the details of the scheme, nay, if its existence, were more generally known throughout the country, it would give an

impetus to the labours of teachers and students, such as the founders of the scheme never anticipated; for there are no limits to the good work that it might originate and accomplish.

Let it be our endeavour, then, to give to it that publicity which we consider so desirable, and to indicate the mode in which those who have not yet been made acquainted with its existence may participate in its advantages.

"The Department of Science and Art is now the constituted machinery for giving State aid to certain branches of instruction in Art, and in certain definite subjects of Science."*

These subjects are:—

I. Geometrical Drawing, &c.
II. Mechanical Physics.
III. Experimental Physics.
IV. Chemistry.
V. Geology, Mineralogy, &c.
VI. Zoology.
VII. Botany.
VIII. and IX. Navigation, Nautical Astronomy, Physical Geography;

and the State grants pecuniary aid to *teachers* who have passed an examination in these branches of Science at South Kensington, and have obtained a certificate of competency, as well as valuable and honourable prizes (elegantly bound books, medals, &c.), to successful *students*, in whatsoever manner they may have been educated,—that is to say, whether by certificated or uncertificated teachers, or by self-tuition. The aid to certificated teachers consists of "certificate allowances," and "payments on results," the first-named being a sum of money for each pupil taught (up to a certain number); and the second, a *further* sum for every pupil who obtains a prize, the amount being regulated by the nature of the prize, 1st, 2nd, or 3rd class, and limited only by the teaching capabilities of the master, and the numbers and industry of the students.†

The prizes of the last-named, known as "Queen's Prizes," consist of the scientific works of Owen, Faraday, Lyell, Tyndall, Carpenter, &c., or the more popular ones of Gosse, Darwin, Rymer Jones, Lardner, and others; and besides these they may, by greater assiduity, obtain "Queen's Medals," of gold, silver, or bronze.

We cannot enter further into details, and must conclude this portion of our subject by stating that the examination of *teachers* takes place annually at the South Kensington Museum, London, about the middle of November, the State defraying the travelling expenses (including cost of living in

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* This extract is from a lecture delivered at the South Kensington Museum, February 4, 1861, by Captain Donelly, R.E., Inspector of Science, "On the Promotion of Science Instruction, by the Department of Science and Art."—It may be obtained by applying to Henry Cole, Esq., C.B., Secretary of the Science and Art Department, South Kensington.—Price 2*d.*

† As regards the income to be derived by teachers from Government grants, we believe that it ranges from £20 to £100.

London) of candidates; and the examination of students is held in the month of May in the locality in which the school or class may be established. There also *self-taught students*, or such as have been taught by uncertificated teachers, have the same privilege of competing for prizes as students educated in the Science school.*

Let us now glance cursorily at a few of the results of this assistance granted by the State towards promoting instruction in Science.

Last March there existed thirty schools and classes in England and Scotland,† and others have since been started, or are in process of formation. There were 111 certificated teachers in Great Britain; and besides these, many tutors not holding Government certificates prepared their pupils for the Science Examinations; several students, too, were successful in obtaining prizes at the May Examinations whose scientific knowledge was the result of home-culture, without any artificial tuition.

It will be very encouraging to young persons of both sexes, who may be actuated by the laudable desire to secure honourable rewards as the result of useful employment of their leisure time, to know that these "self-taught" students have been amongst the most successful in obtaining prizes; Mr. F. W. Rudler, of London, for example, having carried off the gold medal, and Mr. George Tindall, of Huddersfield, one of the silver medals for physiology at the examination last May.

The list of prize-holders also includes many of the fair sex, but so far we do not find one female teacher. One of the probable causes of this circumstance (to which we referred in our last), is the absence of any reference to female teachers in the "Directory," in which the male pronoun is invariably employed in speaking of the teachers; but a still more important one will be found in the difficulties that are presented to young persons of the other sex who may desire to attend the examination in the metropolis—we refer to the hesitation which must necessarily be felt by young girls to travel alone, *second-class*,‡ in winter, and stay without protection in London during the examination. Perhaps those who have wisely projected the scheme may deem this matter worthy of their consideration, and may provide a safe asylum for such female candidates as desire to avail themselves of the advantages offered by the State. It is a subject which must recommend itself warmly to all who take an interest in the employment of women; and if means could be devised to admit these to the privileges of teachers, the number of *students* of the same sex would also be materially increased.

Amongst the various schools that have been established, we know of none that has been more successful, under unfavourable circumstances, than the one at Banbury. It was opened early in the present year, there

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* For detailed information on this subject, we refer our readers to the "Directory" of the Science and Art Department, South Kensington, which may be obtained (price 6*d.*) by applying, or writing, to the Secretary of the Department, Henry Cole, Esq., C.B.

† We have no doubt that the time is not far distant when there will be this number in such places as Liverpool, Manchester, &c., to say nothing of the metropolis, in which seven are already established.

‡ The State only allows the second-class fare.

not being a certificated teacher resident in the town at the time, and we perceive by a report lately issued, that, at the examination held in the school last June, thirty-three out of thirty-eight students passed in physiology: of these twenty-eight obtained "Queen's Prizes" (including James Smart and Charles Taylor, to whom bronze medals were awarded); and out of twenty-four students in zoology, eleven passed the examination, and three secured prizes.

All these young men owe their success and improved culture to the philanthropic exertions of Mr. J. H. Beale, a member of the committee of the school, who undertook the task of instructing them without any prospect of pecuniary remuneration; and also to the zeal and energy of Mr. James Cadbury, the secretary, and one of the originators of the school.

A second branch of Science has been added,—a class in chemistry being now gratuitously and worthily conducted by Mr. J. H. Beesley,* an analytical chemist in the town, who has placed his laboratory at the disposal of the students for the purpose.

In connection with the Banbury Institution we must not omit the mention of Dr. Acland, of Oxford, who has taken a deep interest in its formation and in the movement generally.

Another thriving little institution is the Science School at Wigan, where classes are established under the direction of Mr. E. H. Birkenhead as teacher. This gentleman held, before November last, no less than *seven* Government certificates of the first-class, in physics, geology, &c., and two of the second-class in chemistry, &c.† Our readers will not be surprised to hear that the pupils of so proficient a teacher were *all* successful at the last examination, none having entirely failed, eighteen having obtained "Queen's Prizes," and two, silver medals. Mr. Birkenhead is now also installed as Lecturer on Geology at the Liverpool School of Science. At Wigan, the institution owes its prosperity in a great measure to the active zeal of the Rev. T. F. Fergie, the incumbent of Ince, near that town.

At Liverpool, a school has been established, as already stated, under the most favourable auspices, and we have very good grounds for expecting that it will prove a successful and thriving institution. The active support and sympathy of the Lord President of the Council, the head of the Educational Department of the State, seconded by the eloquence of the Chancellor of the Exchequer, and of other eminent men, could not fail to impress all classes of persons with the importance of the movement, and to enlist their warmest sympathies; whilst the munificence of such men as Mr. William Brown, Mr. Graves the late Mayor, the President of the British Association, and other gentlemen resident in the town and neighbourhood, has rendered permanent that which might, without such aid, have been but a temporary boon to the important town of Liverpool. The school commenced its operations early in December, with about 140 students (including many pupil-teachers who have free admission to the

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* Since this article was written, Mr. Beesley has taken a first-grade certificate.

† He now holds nine first and two second-class certificates.

lectures), besides about twice that number of persons of both sexes, and drawn from every grade of society, who had become subscribers, either annual or to the course on geology, and who are regular attendants at the lectures. There are now in this school, class-lectures delivered on geology, mineralogy, zoology, and botany.

It must not be supposed that the selection of these few eminently successful institutions has been an invidious one; for although we have chosen those with the operation of which we are the best acquainted, to illustrate the progress of the movement, we believe that nearly every class which has been established has been attended with a success more or less marked; and we shall now conclude these observations with a few hints to those who are able and willing to lend their co-operation in the good cause.

First, then, we may mention, that the State requires that a proper room, with firing and lighting, be provided for the reception of the class to be established, and that a Committee be formed for the purpose of taking charge of the diagrams and apparatus, of which Government defrays half the cost. It is hardly necessary to suggest that the best course which can be adopted with regard to the first-named stipulation, is that the "Science School" or class should be established in connection with some already existing institution, such as a Mechanics' Institute, Literary, or Mutual Improvement Society, or Public School. With respect to the Committee, it will be found that the State requires at least five members, one of whom must be the Mayor, Alderman, or a Member of the Town Council, or a person who is at the head of a Grammar School or other Public School. This is easily managed, for the difficulty is not to find men of position who will lend their *names*, but such persons as will give their *time* for the work.

If the movement originates with a teacher who desires to start a class, the duties of the Committee are nominal, as they merely act as a medium by which the State can recognize and reward his labours; but in large towns, where there are to be several teachers or lecturers paid by a Committee of Management, the originators must proceed precisely as though they were establishing a Mechanics' Institution, first raising a small fund to defray preliminary expenses, and then seeking the co-operation of gentlemen to act as teachers (certificated or otherwise) in the school. The Mayor (for the time being) should be induced, if possible, to act as the nominal president, and a connection formed with the Town Council (a precaution necessary to prevent the institution from degenerating into a political or sectarian establishment), so that the school may be a recognized medium of instruction for all classes and denominations.

We believe that when such measures are taken it will be found that the school will be maintained, to some extent, by the donations and subscriptions of persons who will be merely honorary members, and it will then be for the Committee to secure the attendance of the industrial classes by admitting them at the lowest possible charge. Pupil-teachers in schools under inspection should be admitted free (for it must not be forgotten that it is for the education of those who are unable to pay for tuition, that the *State* affords its aid), and teachers in schools, as well as the "industrial classes" should be admitted at a low charge,—*not* gratuitously, or they will not value the instruction.

The great object to be kept in view in a large school, should be to train teachers who will subsequently establish classes in various parts of the town; and it is highly desirable that the institution should be in close proximity to a museum and library, so that the students may there find illustrative specimens of the various objects upon which lectures are delivered in the school, and works of reference to be consulted as the occasion requires. Under all circumstances, we believe that the State adapts its mode of extending aid to the wants, and as much as possible to the desires, of the district in which the effort is being made, and it is always glad to send a delegate from London to aid the projectors with advice and information.

Up to the present time classes have been established, chiefly in small towns; whilst they exist in such places as Dedham, Slaithwaite, Slough, and Accrington, and there are schools in towns like Banbury and Wigan, we do not even find *classes* in such places as Leeds and Hull, where the means of imparting instruction would be so easily procurable, and in Manchester and Birmingham the commencement has only just been made by enterprising individual teachers; but there are as yet no recognized public schools.*

We would finally draw public attention to the fact that this movement is especially deserving of the encouragement of the *middle classes;* for whilst its ostensible and, to a great extent, its real object is to elevate the intellectual condition of the masses, it is opening out to the poorer but more intelligent members of the middle classes such a field as has never yet been presented for honourable, intellectual, and at the same time remunerative employment.†

Many a poor, hard-working professional man, or clerk, will have an opportunity of adding to his limited income by establishing a Science Class, and that too without interfering with his ordinary avocations; and, by the same means, many a respectable and intelligent girl may be saved from misery and starvation!

We hope the good work will prosper, and shall be happy at all times to lend it our hearty co-operation.

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* A communication received from Wm. Fairbairn, Esq., of Manchester, leads us to expect that a school will shortly be established there; and when we mention that the President of the British Association is likely to be the prime mover, it is needless to add that, if undertaken, the enterprise will be sure of success.

† To show that this statement is founded on fact, we may mention, that when an assistant secretary was required for the Liverpool School of Science, whose duties necessitated his attendance two evenings weekly, the salary offered being £20, there were about 400 applicants for the post. Many were schoolmasters, teachers, and gentlemen established in some honourable profession, who were desirous of increasing their incomes.

If those persons had been proficient in any one branch of science, they might have earned four or five times the amount offered, by successful tuition.

Provincial Institutions and Societies.

The large amount of space which we have deemed it necessary to appropriate to the important subject of Science Schools, allows us to do little more than to acknowledge the following Reports, &c.:—

The Wigan Mechanics' Institution comprises a library, newsroom, evening classes, mining and mechanical (science) school, gymnasium, singing class, "Society of Arts" class, public readings and lectures, excursions, a chess-club, and a penny savings'-bank. It has been in existence seven years, and is supported by the leading gentlemen in Wigan and the neighbourhood.

The Liverpool Chemists' Association, intended chiefly for the improvement of young chemists and druggists' apprentices. It commenced its operations in 1854 with 73 members and associates, and now numbers upwards of 186 members.

The lectures are all of the most interesting and practical nature, and the library contains the most important recent scientific works.

Southampton Microscopical Society. The President of this institution, Dr. J. Bullar, says:—

"The social aspect of our society commends it. It is a pleasant way of spending an evening where there is a scientific object of natural interest, and, at the same time, a social gathering of many having the same tastes and objects, and, therefore, the same sympathies. The anatomy of an insect, too, is a more harmless occupation than the minute dissection of a neighbour's natural history. Tea and coffee, pleasant chat with those of like tastes, and then the table covered with microscopes and the specimens explained by one and passed round for each to examine, calling out animated talk on subjects worth discussing, or a short paper read and discussed on the subject illustrated, are civilizing. For science is a civilizer. It refines the tastes and elevates the thoughts, as it is the search after truth for truth's own sake. And in this age, when the progress of the nation and of the world is estimated by the money-value of exports and imports (and in this aspect the world's progress is prodigious and annually increasing), the danger must lie in estimating all things in reference to money rather than to truth. Now, science is a counteracting force. It neither brings wealth to its true cultivators, nor can wealth buy scientific tastes or scientific fame. It belongs to a higher region than 'the diggings.' It must breathe 'a purer ether, a diviner air.' And those who are engrossed in commerce would often do well, for their own content and happiness, by seeking in the recreations of science a complete change of action, thought, and feeling. Obviously the eye service which the microscope requires, trains the eye to minute and discriminative observation, and the hand to delicate accuracy. It leads on, if used scientifically, to the improvement of the scientific powers. The memory, the investigation of causes, the estimation of evidence, the power of distinguishing and of generalizing may be called into activity. But the mind has other and deeper needs than these. The senses lead to the awakening and culture of deeper powers inherent in the soul itself, and the microscope may excite and cultivate, not only the sense of the true, but of the beautiful. Constable, the landscape-painter, said that, pictorially, nothing in nature was ugly; and surely we may say the same microscopically. The higher the magnifying powers, the more minutely extensive the investigations, the more beauty do we see. Even in the unhealthy secretions,—in what look to the unscientific eye like repulsive

fluids, in the very disorganizations which slowly ruin this goodly human frame, the microscope discovers forms of the highest geometrical accuracy, as well as of the most delicate beauty. And this beauty and consummate finish are everywhere, and are found farther and deeper as our powers increase of observing them. Here, too, at every step we find the limitation of our own powers, and the illimitable field of nature; the infinite contrasting with our finite, teaching us 'the moral lesson of science,—humility.'"

Manchester Literary and Philosophical Society, Microscopical Section.—With the permission of the author, we reprint the following paper "On Preparing and Mounting Insects," by Mr. HEPWORTH:—

"I herewith send you a specimen, for the inspection of the Microscopical section of the Literary and Philosophical Society, regretting I have not a duplicate to present to the members. Having seen and purchased some whole insects mounted by some gentleman (unknown to me) so beautifully, it caused me to make a series of experiments, which have resulted in producing the specimen before you. Although I have mounted great numbers, our unknown friend still bears the palm. The plan I have adopted, and which has been as yet the most successful, is the following: After destroying the insects in sulphuric ether (methylated being cheaper), wash them thoroughly in a wide-necked bottle (half-filled) with two or three waters; the delicate ones require great care. Then immerse them in liquid potash (or Brandishe's solution, which is stronger than the usual preparation), and let them remain a longer or shorter time, according to their texture. When ready to remove, put them one by one into a small saucer of clear water, and with a camel-hair pencil in each hand press them flat to the bottom, holding the head and thorax with the left-hand brush, and apply pressure with the other from above, downwards, giving the brush a rolling motion, which generally expels the contents of the abdomen dissolved by the potash. If you stroke the parts you are apt to separate the abdomen from the thorax. A minute roller of pith or cork might be used instead of the brush. In larger objects, use the end of the finger to flatten them. Large objects require more frequent washings, as it is desirable to remove the potash thoroughly, or crystals are apt to form after mounting. Having placed them on the slides with thin glass covers, tied down with thread, dry and immerse them in rectified spirit of turpentine; place the vessel under the receiver of an air-pump, and keep it exhausted until the turpentine has taken the place of the air bubbles: they are then ready for the application of the balsam. Larger objects may often, with advantage, be transferred to a clean slide; as, during the drying, there is considerable contraction, and an outline often remains beyond the margin showing this. When closely corked they may remain in the spirit for two or three months. As you take them from the bottle, wipe as much turpentine off as possible before removing the thread; and when untied, carefully wipe again, placing the finger on one end of the cover whilst you wipe the other, and *vice versâ*. By this means you remove as much turpentine from under the cover as is necessary; then drop the balsam, thinned with chloroform, upon the slide, letting the fluid touch the cover, when it will be taken in between the surfaces by capillary attraction; and after pressing the cover down it may be left to dry, or you may hold the slide over a spirit-lamp for a few seconds before pressing down the cover. If heat is not applied they are much longer in drying, but are more transparent. If made too hot the boiling disarranges the objects, and if carried too far will leave only the resin of the balsam, rendering it so brittle that the cover is apt to fly off by a fall, or any jar producing sufficient percussion. Never lift the cover up if possible during the operation, as there is danger of admitting air. A

few bubbles may appear immediately after mounting, but generally subside after a few hours, being only the chloroform or turpentine in a state of vapour, which becomes condensed."

Mr. J. B. DANCER read a very interesting paper "On Cleaning and Preparing Diatoms, &c., obtained from Soundings on the 19th November, 1860;" and Mr. G. MOSLEY one on the same subject, January 21, 1861.

Report of the Radcliffe Trustees on the Transfer of the Radcliffe Library to the Oxford University Museum, by Dr. H. W. ACLAND, Regius Professor of Medicine, Oxford; also, by the same author:—

Remarks on the Oxford Museum, containing an excellent plan of the new building, &c. &c.

At the *Liverpool Naturalists' Field Club* ten prizes were distributed at the meeting held for the purpose last October. Amongst the prizeholders, Miss Gibson collected and classified the largest number of species of plants during the season, namely 124, and received as prizes "Babington's Botany," and "Hibberd's Aquarium." The number of species collected and arranged by some of those ladies who were precluded from competing (in consequence of their having already received prizes), amounted to nearly 200. The society continues to flourish.

REVIEWS.

THE UNITY OF THE HUMAN SPECIES.*

HOWEVER M. de Quatrefages' book may have been received in France, we may venture to predict for it a remarkable degree of success if it should be translated and published in the English language.

Espousing, as he does, the popular doctrine of the origin of the human race, his evidence in its favour, which is based solely upon a consideration of the question from a scientific point of view, will be welcomed by all who are indisposed to deviate from the beaten path of tradition; whilst the most enterprising and latitudinarian inquirers, who hold contrary views to those adopted by the author, will be pleased to find themselves treated with respect, and their tenets combated with good temper and moderation.

The work will be read with additional interest in England, in consequence of the practical application which the author has made of some of the theories of Mr. Darwin, who will no doubt be astonished to see himself appear therein as the advocate of the "unity of the human species," and of the "immutability of species" in general.

So far as our limited space will allow, we shall endeavour to present to our readers a sketch of the contents; and they will then be in a position to judge of the correctness or otherwise of our statements.

As already observed, in advocating the "unity of the human species," the author leaves entirely out of account all theological and moral considerations, and throws himself completely upon the resources of science, of botany and zoology, physiology, medical statistics, ethnology, and the distribution of animals over the globe.

Often, he tells us, he had been tempted involuntarily to introduce evidence of a theological and moral character, but he always erased the words and fell back upon his scientific resources; his reason being, that inasmuch as he treats of a subject which more than any other belongs to the domains of the natural sciences, he wishes "to remain exclusively a naturalist, that he may preserve his right to address *all* men, and in order that he may lead the partisans of the most widely opposed doctrines upon neutral ground, on which no one, whatever may be his creed or instincts, has a right at this day to refuse to enter, and where all comers must indubitably be of one and the same mind."

Passing rapidly in review the different realms of nature, both inorganic and organic, the author leads his readers to the consideration of what he terms "The Human Kingdom."

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* "Unité de l'Espèce Humaine." A. de Quatrefages. Hachette, Paris.

"By turns," he says, "man has been made to constitute a special *kingdom*, a *branch* of the animal kingdom, a *class*, an *order*, a *sub-order*, a *family*, a *sub-family*, a *genus*, a simple *species* of an order in which he has found himself closely linked together with the apes!

"It is not for me to discuss all these opinions, some of them of so strange a character; it will suffice that I should justify the one which I have held for many years, and which day by day I am more disposed to regard as the only true one.

"In my estimation man has as fair a title to be classed distinctly from the animal kingdom as the latter may be said to differ from the vegetable kingdom. He alone should constitute a separate realm, the *human kingdom*,* which is characterized by distinctive features of the same order as those which separate from one another the primordial groups that I have just enumerated."

The title of man to a separate kingdom in nature is found not in his anatomy, nor yet in the mode in which he exercises his animal functions; not in the possession of a voice, nor even in those emotions which are manifested so strongly in the human race. All these the author is willing to concede in a greater or less degree to the higher animals with whom man holds them in common. The attributes that entitle him to the distinction accorded to him are (as the reader will doubtless anticipate) his sense of right and wrong, his consciousness of the existence of the Deity, and his hope of immortality.

As there are, however, many authors who have denied to some of the most degraded races of men the possession of any of these attributes, the narratives of Dr. Livingstone and of other travellers are quoted to prove that even the most barbarous tribes possess at least the germs of these faculties; for even the idol-worship of the most debased Polynesians affords to the author sufficient evidence of the existence of religion in their minds.

He thus concludes his review of this portion of the subject:—"In order to follow Linnæus step by step in the definition of the nature of man, his characteristics, as he would be *zoologically* † designated, are—*Man is a body, or rather an organized being, living, feeling, moving spontaneously, and endowed with morality and religion.*"

Having thus sought generally to establish for mankind the major position of being so far superior to the animal races as to occupy a separate realm in nature, the author now descends to the consideration of "species," with a view to show that there are no specific differences between the *varieties*, as he considers them, of the human race.

He regards species as the "*unity*" of which all other subdivisions of the animal kingdom are composed (genera, families, orders, &c.), but "species" is itself divisible into *fractions*, called *varieties*.

Now, the question at issue between the advocates of that theory, which includes all the peoples of the earth in one species ("monogenistes"), and those who believe them to consist of more than one ("polygenistes"), is, whether the distinctions which characterize certain human groups are such as to constitute each a distinct species or "unity," or whether they amount only to a variety or "fraction."

This being the case, it is of primary importance that our readers should

* "Le règne homminal, ou règne humain."

† We beg the reader to remember this expression, as we shall revert to it in our criticisms.

form a correct estimate of the term "species," which is indeed the pivot whereon the whole argument turns; and as M. de Quatrefages passes in review the various definitions that have been applied to it by the most eminent writers on the subject, we shall extract the most important of these, representing the opinions of different naturalists. The definition of the term has been based upon two distinct phenomena, namely, the *resemblance* between individuals and their *descent* from similar individuals, or, as the author has it, "resemblance" and "filiation."

To place the inquiry in a clear and comprehensible manner before our readers, we will state it thus:—If there were placed before us two plants or animals closely resembling one another, and we were asked to decide whether or not they belong to the same species, would it suffice if we compare them with other animals; and finding that they resemble one another more closely than they resemble any others, we give it as our decision that they belong to the same species? Or is it necessary that we should first inquire into their parentage, in order to ascertain whether or not they were descended from the same original couple; and if they were not so descended, must we then decide that, however closely they may resemble one another, they are not of the same species? Or if they were, and yet were ever so *dissimilar*, must we pronounce them to belong to the same species?

The various replies that have been given to these questions may be found in the following opinions quoted by M. de Quatrefages as to what constitutes a species:—

RAY.—Vegetables which have a *common origin*, and are produced from seeds, whatever may be their apparent differences.

TOURNEFORT.—An assemblage of plants which are distinguished by some particular characteristic.

BUFFON.—Species is nothing else than a constant succession of similar individuals which reproduce themselves.

DE CANDOLLE.—An assemblage of all those individuals *which resemble one another more than they do any others; are able by reciprocal fecundation to produce fertile individuals, doing so by the generative process, and in such a manner that by analogy they may be supposed all to have been descended from one single individual.*

VOGT.—The reunion of all individuals which originate from the same parents, and are either themselves similar to the original stock, or became so through their descendants.*

LAMARCK only regards "species" as a relative expression, and for him it has no fixed existence. He believes in the transmutation from one species to another, and in the formation of new species, "through a tendency," says M. de Quatrefages, "to satisfy certain wants," and through the results of certain spontaneous acts of the individual.

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* M. Vogt here refers to the recently discovered phenomena of "alternation of generations," which may be briefly and popularly described as follows:—From a pair of individuals proceeds an offspring so different to the parents, that it appears to belong to a different order. These young ones are usually barren in the ordinary sense; but by means of offsets, or some abnormal process, they produce a generation of individuals which are again fertile, and exactly resemble their "grandparents," if they may be so termed.

Finally—After considering to what degree of variation individuals of the same species are liable, M. de Quatrefages himself thus explains the meaning of the term :—" *Species is an assemblage of individuals more or less resembling one another, which are descended, or may be regarded as being descended, from a single primitive pair, by an uninterrupted succession of families.*"

Having thus defined the meaning of the term, the author next brings forward his evidence to prove that species is *immutable;* that is to say, that it never has varied since the commencement, and that there can be no transition from one species to another.

He adduces numerous examples in nature in support of this opinion, stating that there are trees in existence which must be thousands of years old, and which are still precisely similar to individuals of the same species, of recent growth.

Amongst others, he refers to a yew-tree 3,000 years old, and a Boabab-tree which is estimated at 5,000 years.

Another interesting example is found in the discovery of loaves of bread in the catacombs of Egypt, containing parts of the wheat-plant, which on examination proved to be precisely the same as that now cultivated.

Nor is the author arrested by the limits of the historic period, for, on the authority and experience of Michelet, he mentions the fact that near Dôle the seeds of a plant, *Galium Anglicum*, which had been found in the Diluvial deposit, had preserved their vitality so far as to germinate, and that they had produced plants precisely the same as the existing species. Some of the fossil remains of Mammalia, too, that are found in bone-caverns show that the animals exactly resembled species now to be found on the surface of the globe. From all these facts, the author concludes that species is immutable, and not subject to variation in time.

From the consideration of " species," he now proceeds to characterize " varieties " and " races " which represent, as it were, the amount of variation of which the first-named (*i. e.* species) is susceptible.

We cannot follow him through his discourse, but must be satisfied to extract his definition of " *variety*" as " *an individual, or an assemblage of individuals, belonging to the same sexual generation, but distinguished from the other representatives of the same species by one or more exceptional characteristics,*" and that of "*race*" as " *the assemblage of individuals belonging to one and the same species, having received and transmitted by means of generation the characters of a primitive variety.*"

In other words, according to M. de Quatrefages, a *variety* is characterized by a deviation from the original species, and a *race* is a variety which has multiplied and become permanent—a *perpetuated variety* in fact.

These varieties or races are of three kinds: first, those which have acquired certain peculiarities through the influences brought to bear upon them by nature only, without the intervention of man ; secondly, cultivated varieties, in which man has been the modifying agent ; and, thirdly, those varieties which, having been subjected for a time to the influence of the human race, have escaped and relapsed, as it were, into their natural condition. As the individuals which were originally tamed or cultivated had disappeared, the emancipated varieties thus became the representatives of a new race.

All these agencies, however, the author has grouped together under the title of "*milieu*" or "medium" (meaning thereby the "condition of existence"

a term embracing "every influence, whether physical, intellectual, or moral." The "medium,"* he goes on to say, renders the existence of varieties absolutely necessary; for if species did not yield to external circumstances—that is to say, if individual forms were unable to bend to external circumstances by which they are surrounded, to such an extent as to form *varieties*—they would die out, and the "species would cease to exist."

So great is the influence of the "medium," that it gives rise to varieties sufficiently marked to cause them to be mistaken for different species.

M. Decaisne, who is attached to the Museum of the "Jardin des Plantes" (where the author also fills a professorial chair), obtained from the country, seeds of a well-marked species of plantain, and sowed them in the garden of the Museum. They produced seven forms of the plant, each of which had up to that time been regarded as a distinct species. These did not differ on trifling points alone, but in the form and covering of the leaves, the roots, &c.; indeed, so great were the distinctions between them, that he considered the error of Linnæus and his successors quite pardonable when he classed them as separate species. Allowed to remain in the same "medium" (in this case, the same soil, temperature, &c.), these varieties became permanent; transplanted elsewhere, their characteristic features disappeared; and they came to resemble one another so closely that it was easy to distinguish them as merely varieties of the same species.†

But the author is not content to draw his examples from the vegetable kingdom; and where does the reader suppose that he finds his most convincing evidence in favour of the unity and immutability of species?

In the experience of Charles Darwin; and it is extracted from the very work, in which that author seeks to show the probability of the transmutation of species.

Here are the words themselves:—

"Mr. Darwin has gone still further. Led by his general studies to occupy himself specially with the problem of pigeons, he determined to probe it to the bottom. He surrounded himself with all the documents collected before his time; procured all the European races, and those of the English Colonies, entered into communication with the chief pigeon-fanciers in London, joined two special clubs, and himself tried numerous experiments."

"It was only by seeking to attain the truth by every possible means that he felt himself warranted in arriving at a conclusion; and his conclusion is most affirmative, in favour of the unity of species. He considers the Rock-pigeon (*Columba livia*) as the original stock from which all domestic pigeons are derived." . . . . "Finally" (says M. de Quatrefages) "the author sees a proof of the unity of origin in all the races of pigeons, in this fact, that the most dissimilar may be crossed and produce mongrels that are indefinitely fruitful. This is, indeed, a full and entire confirmation of the preceding conclusion, as the reader will understand later on."‡

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* The reader will understand that when we employ this term after the author, it bears the construction of "influences or conditions of existence."

† A still more striking example of the power of man to modify species or varieties is to be found in the experiments of our esteemed contributor Professor Buckman upon the wheat-plant, as described in our first number, article "Corn."

‡ We are intentionally literal in our translation of these passages, as we desire to keep as close as possible to the original language of M. de Quatrefages.

The author subsequently reverts to Mr. Darwin and his theory; and we shall not fail to give the reader an opportunity of participating in the interesting association.

Having enunciated the principle that varieties present gradations as they recede from the specific type, or that a "species" is composed of different varieties blending into one another, the author now proceeds to apply this principle to the human race.

He shows that the most dissimilar types of mankind are brought into relationship by intermediate varieties, just as in the case of the pigeon; that on the continent of Africa, where we find the pure negro race on the one hand, and the white on the other, there are also intermediate tribes which present the distinctive features of both, and which form a connecting link between them.

That these two types (the black and white) only constitute *varieties*, the author finds in every way probable, not only in consequence of the presence of intervening groups, which form a transition from one to the other, but because intermarriages of these races are frequent and fertile—a phase of the subject which he treats more fully in a subsequent part of his work.

He next examines the nature and extent of the variations presented by the vegetable and animal *races*, as well as by man; showing, first, that the two former are characterized by *great* anatomical and physiological (and in animals psychological or mental) differences; and then that *races* of men also exhibit similar differences, but that the *extent* of such differences is much greater in animals which are acknowledged as *varieties* only, than in any known races of man.

To establish his position in this respect, he brings forward a mass of evidence, referring to the great difference in the *size* of certain animals of the same species, as compared with the height of different races of men, and selecting extreme cases as illustrations. Passing on to the alleged relationship, which has been found to exist between the human species and the ape, in consequence of the close resemblance between the skeleton of the aboriginal Australian and that animal; he remarks that such doctrines may be very convenient for our settlers in justifying their treatment of the natives, as though they belonged to the animal races; but he quotes several well-known travellers, to show that many of these degraded aborigines possess all the perfect attributes of Europeans.

He says also (on the authority of Dawson, Cunningham, &c.), that individuals brought to England had been educated to become true gentlemen, but that "*owing to the prejudice of colour exhibited towards the negro in all colonies, especially in English ones*," it was no wonder that when these "gentlemen" returned to Australia, they fell back into their pristine barbarism. He thus seeks to show that the most degraded races of men are susceptible of being educated; and that they present the characteristic features of *varieties*, inasmuch as they may relapse into their original condition.

Many of the author's statements concerning our Australian colonies are curious and instructive, as coming from one who writes without feeling or prejudice; for example, whilst endeavouring to show that in every respect widely different races may become approximated, he says, "In Australia the white man falls in the scale of civilization at the same time that the negro

rises;" and concludes with the observation, that "between the European and the savage of New Holland there is less psychological difference than between many individuals in one and the same *race* amongst the lower animals." To explain the diversity of human groups, there is no need, he says, "to have recourse to the hypothesis of the multiplicity of *species;* for the multiplicity of *races* and the unity of species suffice."

It would be impossible to follow the author, ever so cursorily, in his disquisition upon the *origin* of varieties and races of animals, and the influence exercised by the "conditions of existence" in their formation. The numerous instances quoted, of abnormal human beings possessing some characteristic feature, which, had it been natural, would have distinguished them as individuals of a separate *species*, are deeply interesting, and will, no doubt, be considered so by Mr. Darwin, concerning whom the author expresses himself as follows: "I regret that I am not able to dwell longer upon the work of Mr. Darwin, for there exist between my ideas and those of my learned and ingenious brother naturalist much striking similarity, and also some differences, which it would have been useful to consider. The views of Mr. Darwin grapple with the very origin of things, and it appears to me difficult for positive science to mount to such an elevation. *He* seeks to explain the derivation of every species, and causes them to proceed from an unique type, modified during an incalculable series of ages, which include the geological eras. *I* confine my researches to those species which live at this day, and have existed only during the present epoch. But what he says of the formation of *species*, I had already stated in 1846 concerning the formation of *races*, so much so, that if one word be substituted for the other, we shall be found to agree pretty nearly on all general points concerning this order of facts."*

It will be seen from the foregoing extract, that M. de Quatrefages attributes the formation of *varieties* and *races* to the causes assigned by Mr. Darwin for that of *species;* indeed, he does not hesitate to employ many of Mr. Darwin's phrases, such as, for example, "the struggle for existence," &c.

One of the instances that he gives, of the degree of variation to which races are liable under changed external conditions, is so novel and characteristic, that we feel sure it will be interesting to the reader, and we therefore extract it *in extenso*. He is describing the transition from the Anglo-Saxon to the Indian type, as exhibited in the Anglo-Saxon-American, and says, that—

"Already in the second generation these traits of the Indian type are visible, which cause him to approximate to the Iroquois and Cherokees. Later on, the glandular system is restricted within the narrowest limits of its normal development; the skin becomes dry as leather, loses its warm tint, and the rosy colour of the cheeks, which is replaced in the man by a lemon yellow, and in the woman by a faded pallor. The head shrinks in its proportions, and becomes round or pointed, and covered with long, sleek, dark-coloured hair; the neck elongates; there is a great develop-

* Lest this extract should lead any of our readers to suppose that Mr. Darwin has only reiterated the opinions (with modification) of M. de Quatrefages, we must add that our author distinctly states that notwithstanding the curious coincidence referred to, Mr. Darwin could not have known of his opinions, which were expressed in his lectures, but not published.

ment of the zygomatic (cheek) bones and of the masseter muscles. The temporal fossæ are deep ; the jaws massive ; the eyes deeply set, and approaching one another very closely ; the iris is dark-coloured, and the glance piercing and savage. The shafts of the bones, especially of the anterior extremities, are long; so much so, that in France and England a special form of glove is manufactured for the American market, having the fingers exceptionally elongated. The cavities of these bones are small ; the nails soon assume a lengthened and pointed shape. The pelvis of the woman approaches that of the man in form. We have softened down some of the harsher features in this description."

The next link in the author's chain of reasoning, whereby he would prove the unity of the human species, is the production of *hybrids* and *mongrels*. The former, as is doubtless well known to all our readers, are the results of an intercrossing of two individuals of two different *species :* the mule, for example, being the *hybrid* of the horse and ass ; whilst, on the other hand, *mongrels* are derived from individuals of different *races* or *varieties*, of which numerous instances present themselves in our races of domesticated animals.

With reference to these phenomena, the evidence adduced by the author serves to show that the production of mongrels is always easy, however greatly the races may differ from one another. It takes place daily between individuals left entirely to themselves, and man has often more difficulty in preventing than in promoting the intercourse. Neither does it interfere with the fertility of the offspring, which is equal to, if not greater than that manifested in the union of individuals of the same race.

Hybridism, or the intercrossing of *species*, is in the immense majority of cases impossible, even where the two species brought into relation with one another present the most striking affinities. "It is extremely rare amongst free, or wild individuals, and in captive or domesticated species it is brought about only with the aid of manœuvres, which often fail to produce a result. Under its influence, even in the most favourable cases, fertility (almost with one exception only) becomes irregular, and is sometimes diminished to an enormous extent."

Much space is devoted by the author to the consideration of these phenomena, and he seems almost to have exhausted the subject, for his evidence is drawn from every conceivable source. His dissertation upon the past and future operations of man, and the influence which he exercises in the formation of hybrids and mongrels, is deeply interesting, and well deserves a passing notice. He asks whether it will ever be possible to produce fertile hybrids, and his reply is, "*probably* not ;" but "the power of man is very great, and less than all others are we disposed to assign to it limits based upon our present knowledge. This power has already been strikingly exhibited in the order of facts to which we have referred. There is not known a single case of hybridism between *wild* species," (*i.e.*, spontaneous crossing of species in the wild state,) "but man has obtained fertile unions, not only between species that have submitted for centuries to his domination, but between those which it is difficult to tame, between the tiger and lion. He has done even more, when, after innumerable fruitless attempts, he has at length created *series* of hybrids."

In concluding his remarks on hybrids and mongrels, the author says that if we ascend in imagination to the origin of mongrel races, we find them

decomposed into families, every one the progeny of a father and mother; with each preceding generation the number of these families decreases until we arrive at the initial term of *an unique primitive pair.*

"Did this pair really exist, or were there at the commencement many pairs exactly alike? This is a question of fact, with which science is unable to deal, for neither observation nor experience furnishes any data on this head." The author is disposed to think that each species commenced with a single pair.

And now we come to the application of these principles to the human inhabitants of the globe. If the crossing of various dissimilar groups of men were an impossible or even a difficult process, and in the latter case the resulting progeny barren, (*hybrids* in fact,) then these groups would constitute *species.* If, however, the reverse be the case, and the result of an intermixing of these groups be characterized by the peculiarities of the mongrel, then, of course, the author considers himself justified in concluding that they are simply races or varieties.

For the establishment of the latter position he collects and advances a great amount of testimony. We shall quote one or two of the most striking examples which it includes.

Lislet Geoffroy, engineer in the Mauritius, was the son of a negress of humble origin, and of a Frenchman of good standing. "In his colour, features, hair, and even in the characteristic odour, he reproduced all the peculiarities of the maternal race, but his intelligence and sentiments were entirely European." The account concludes by stating that he died a corresponding member of the Institute of France. Another case cited, is one where of "twins, who were incontestably proved to be by the same father," the one possessed all the characteristics of the negro race, and the other those of the white.

Again, it is shown that in Mexico *there are at least fifteen intermediate grades between these two races.* But, perhaps, the most striking evidence advanced by the author in favour of his theory is the publication of an ordinance in California, forbidding the marriage or intercrossing of the two races (white and black), under heavy penalties; "in which case," says the author, "the Californian legislature acts precisely in the same manner as the proprietor of a pure breed, which he desires to preserve from all admixture (deterioration); * * * *it is in order to prevent the fusion, the amalgamation of races.*"

We cannot possibly follow the author through the remainder of his able work, in which he treats of crossed races of men; of the influence of external conditions upon the production of such races; of the theory of Agassiz (from which M. de Quatrefages dissents), who believes certain groups of men to have been distinctly created in various parts of the globe along with the fauna and flora by which they are surrounded. Nor can we accompany him in the consideration of theories concerning the migrations by which the various continents and islands were peopled from *one* centre.

Suffice it to say that the author believes (on purely scientific grounds) not only that the human families have all had their origin in a single pair, but that all evidence tends to the conclusion that Central Asia was "the first cradle of man," from whence, radiating in every direction, "the human tribes went forth to people the most distant solitudes."

We have filled so much of our space with this cursory sketch of M. de Quatrefages' deeply interesting volume—a course with which we feel sure our readers will be better pleased than they would have been with any lengthened criticisms of our own—that we have but little room left to comment upon its merits.

In the first place, we must be orthodox, and find fault. M. de Quatrefages is a special pleader; an honest and truthful one, it is true; but a special pleader, notwithstanding; and we must therefore not be surprised to find that here and there his enthusiasm has carried him into the expression of extreme opinions.

However great may be our sympathy with the animal races, we plead guilty to the weakness of preferring, at least, a separate *order* for ourselves; but at the same time, we can hardly go to the length to which our author does, of requiring a distinct *realm* in nature for our race. It is true some of us have Divine attributes; but if mankind be all of one species, at least there are many who stand so low down in that species that they approximate *very closely* to the Simiæ,—too closely to admit of a line of demarcation being drawn such as that denoted by our author. But we need only refer to his own pages in order to show that no such distinction exists, and that Man must still be placed at the head of the animal kingdom. The whole argument for the unity of the human species is based upon the physiological analogies existing between man and the lower animals, and upon the phenomena which accompany the life-history of both.

Nay, that very being whom the author would sever from the animal races, as distinctly as he separates the latter from the Vegetable Kingdom, is almost in the same breath described by him "zoologically," not in words alone, but in *fact*.

The day may, and we trust will come, when man will no longer be an *animal;* but so long as an author derives his most cogent reasons for a belief in the unity of our species from the "fertility of mongrel races," &c. &c., it hardly seems consistent that he should disconnect him from the animal realm.

There is another question, too, in which our judgment may perhaps be a *little* biassed by the author's strictures upon our treatment of the Aborigines in Australia, but on which our views and his do not coincide.

One of his arguments in favour of the unity of our species is founded on what he deems to be the fact, that there is less difference between the most degraded Australian and the most enlightened European than between many individuals even of the same *race* amongst the lower animals. Against such a theory we must enter our protest, and although we rarely have recourse to the *argumentum ad hominem*, yet, in this instance, it appears to us so convincing that we shall indulge in it, and at the same time apologize to our author for the odious comparison which his "theory" has suggested.

A lady friend, who has resided many years in Australia, once informed us that the natives used to enter the inclosure attached to her house, where logs of wood were stored, and, half-naked as they were, squatted down and regaled themselves with great *gusto* upon the white maggots which inhabited the logs. Sometimes they even entered the house in search of greater dainties (of what they consisted, our friend did not state; probably of mice); and

then, if she happened to be at the top of the house at the time, there was no need that any one should intimate their visit, for the indications thereof pervaded the whole dwelling, and she soon called out to the servants "to put the natives out!" For the *other picture*, we will allow M. de Quatrefages to choose his subject amongst those enlightened audiences to whom his eloquent discourses are delivered, and then let him show us any two individuals, in the same race of *animals*, which present so wide a difference as do these.

The author, too, exhibits a little weakness, in refusing (as he often does) to admit palæontological evidence, excepting where, as a special pleader, it answers his purpose so to do; for instance, in the case of the remains found in "bone caverns." And again, we cannot reconcile his admission of the possibility that man *may* one day be able to form *new species*, as well as new varieties, with the contents of his chapter on the *fixity* of species.

But if these be indications of feebleness or contradiction in his argument, they are more than atoned for by the boldness with which he enters the enemy's camp; takes up the weapons of Mr. Darwin, and employs them to defend the "immutability of species" in general, and the unity of our own.

What influence our author's reasoning will have upon the views of the naturalist referred to we are unable to conjecture.

Will Mr. Darwin clip his wings, and cease to speculate? or will he thank M. de Quatrefages for having accompanied him thus far on his journey, and bidding him farewell, travel on alone?

Will he believe in the fixity of species, or exclaim: "In comparison with your extra pairs of toes and fingers, transmitted from generation to generation, or with your scaly skins, inherited by one family after another, my elongations of the neck or legs are mere trifles"!

He may say, "It is you, not I, who create new species by 'hereditary transmission of peculiarities,' the 'struggle for existence,' and your '*milieu*;'" or he may, on the other hand, agree that what *he* has regarded as a permanent moulding, and, as it were, a creative cause of new species, is only a wise modification of existing species within the limits of varieties and races, to adapt them to the varying influences of nature.

We are not a partisan; and leave our two eminent inquirers to reconcile their differences, and seek earnestly to arrive at the truth.

After what we have said, we feel sure no further recommendation of M. de Quatrefages' book is necessary. It is the work of a great naturalist, a pleasing writer, and a most instructive teacher, and (as already stated) is sure of a welcome in England whenever it shall be translated into our language.

THE OPHTHALMOSCOPE.*

THE reader must acquit us of the desire to perpetrate a pun, when we say that nowadays every art and every science has its peculiar "scope:" zoology and botany their microscope; physics its telescope and gyroscope; photography its stereoscope; ornamentation its debuscope;

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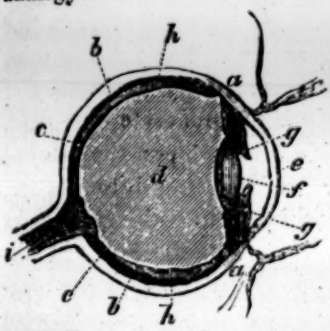
* "A Practical Treatise on the Use of the Ophthalmoscope." By J. W. Hulke, F.R.C.S. Churchill.

and the practice of surgery has, besides others, its stethoscope and its *Ophthalmoscope*. A few words of explanation as regards the last-named, (an instrument which derives its designation from two Greek words, signifying "to behold," and "the eye,") will probably be interesting to some of our readers.

First, however, it will be necessary for us briefly to consider the structure of *Nature's* wondrous and perfect instrument, which is in this case the active as well as the passive agent—the observer and the object of investigation,—we mean the human eye,—and then we shall be able to understand more clearly the mode in which the other instrument is applied.

The eye has been aptly compared to the "camera" of a photographic artist, and we shall find that a survey of its parts fully bears out the analogy.



The whole of the posterior portion (see woodcut, from *a a*) backwards constitutes the *box* or dark chamber, the walls of which are composed of an outer membrane of a milk-white colour and firm fibrous consistency (the sclerotcia, *b, b*), and of an inner one (the choroid, *c, c*), in which the colouring matter (pigmentum nigrum) is deposited, that darkens the inner portion of the chamber. The last-named is however not empty and hollow as in the camera, but it is filled with a jelly-like transparent substance (*d*) (the vitreous humour), which allows a free passage to the rays of light. Anterior to (*a a*) the chamber, we have the analogue of the brass tube and lenses of the camera. There is the external lens (the cornea, *e*), between which and the "crystalline" lens (*f*) we find the curtain or diaphragm (*g g*), possessing, in the eye, that remarkable power of contraction and dilatation whereby more or less light is admitted, as circumstances may necessitate, and which is called the "iris," in consequence of the hues imparted to it in different individuals by its contained colouring matter. Between the outer lens (cornea) and the inner one (crystalline lens), is the "aqueous humour," a limpid fluid which fills the anterior chamber; and, lastly, as the reader is well aware, there is the aperture in the iris or diaphragm—the window of the eye we might term it, if it were not better known as the "pupil;" being so called on account of the little image which it reflects of him who examines it.

We have thus all the essential parts of the camera; or, to speak more correctly, the camera has many of the essential parts of the eye (for we have only named a few of the most prominent); and now we require in the latter, the "sensitive plate," which receives impressions of external objects. This is found in the *retina* (*h*), a delicate membrane, lining the whole of the concave surface of the "choroid," and over which are distributed innumerable ramifications of the *optic nerve* (*i*), which pierces the back of the eyeball a little below the posterior extremity of its axis. The retina it is that receives the external image after it has passed through the several media already named,—the cornea, pupil, lens, and vitreous

humour; and thence the image is conducted by the optic nerve to the brain. The retina, too, is that portion of the eye in whose examination the power of the ophthalmoscope is most successfully employed.

The instrument is a very simple one, and its action is easily understood; it is in fact nothing more than a little concave metallic mirror which reflects a bright light into the pupil of the eye, and it has a small hole pierced in the centre, through which the oculist may look into the eye of his patient. A magnifying lens placed between the mirror and the patient's eye, so as to enable the oculist to examine any symptoms of disease that may present themselves completes the simpler forms of the instrument.

A reference to the following woodcut will assist the reader to form an idea of the mode in which it is applied. The illuminating agent is a jet of gas conducted from the wall by means of a flexible tube, and surrounded by a chimney of blue glass to moderate the light. The rays falling upon the polished mirror are reflected into the eye, into which the observer looks through the small hole in the mirror and also through the magnifying lens that intervenes between the observer and the eye of his patient, and which he can adjust according to his wishes.

Should the reader desire to know more on this interesting subject; to study the optical principles concerned in the operation of the instrument, or the various forms which it has assumed in the hands of skilful opticians and oculists; should he wish to see the "ophthalmoscopic" appearance of the interior of the ocular chamber in health or disease,—we must refer him to the able work before us, and he will find it to be one of the first order. It is not intended (as are many such volumes) as a professional advertisement for the author; but is an essay, for which a prize was awarded to Mr. Hulke by the Royal College of Surgeons in 1859. The various forms of the instrument of which it treats are exhibited in well-executed woodcuts, and the exquisite chromo-lithographs by Messrs. Day and Son, illustrative of the appearance of the retina in health and disease, require no such apology as the author considers it needful to offer for them in his preface.

Although an eminently *practical* treatise, it is, however, not exactly a popular one; but we have no hesitation in cordially recommending it for the perusal of all medical practitioners and students, as well as to reading societies, public libraries, and to such readers as are in some degree acquainted with anatomical science.

On "Food." By EDWIN LANKESTER, M.D., F.R.S. Hardwicke.

Dr Lankester's Lectures on Food have an extensive circulation. This is not to be wondered at, for they are intended chiefly for the masses—the "working classes," as they are denominated.

We affirm, without hesitation, and at the risk of incurring censure for "favouritism" towards a friend and correspondent, that this excellent little work should be carefully read by all sections of the community, by parents and children, teachers and taught.

They may, perhaps, find here and there a little tautology, which the author would have done well to avoid, or, even in the hurry of "preparing proof," a little want of elegance in diction; but Dr. Lankester is a "working man" himself, and his work, in this instance, has been to teach us concerning our daily food and luxuries, which he has done most efficiently.

Not being a man of extreme opinions, he will be heard with respect by all; and whilst we direct general attention to his work, as treating agreeably of the comforts of every-day life, tea, coffee, chocolate, spices, &c., we would more particularly recommend those chapters in which he deals with "wine, spirits, alcohol, and tobacco," to those very numerous fellow-countrymen who are either not aware of the injurious effects of over-indulgence in alcoholic liquors, or, being aware of them, have not sufficient self-control to resist their pernicious influences.

Forest Creatures. By CHARLES BONER. Longmans.

It is difficult to conceive of a tender-hearted sportsman. One cannot imagine that he who hunts a panting hare to death, or who can look on calmly whilst his dogs tear into pieces a trembling doe, is capable of feeling gentle motions.

But if Mr. Boner feels as he writes, we are bound to conclude, that a sporting man does not necessarily possess a heart of stone, and that he may be as susceptible of love and pity as his fellow-men.

Indeed, the feature by which, above all others, the work before us is characterized and rendered interesting, is the description of the love exhibited by forest creatures for their offspring. We shall extract an instance of this attachment, and the reader will obtain some idea of Mr. Boner's style of writing.

The first relates to the female of the Wild Boar; the second to that of the Roebuck:—

"But generally the female parent fulfils her duties with true maternal care, and leads and watches over her offspring with tenderness and anxious love. Directly she hears one cry, she hastens to the spot. She calls them around her as a hen her chickens, if their safety seems threatened; and when danger approaches, she sets off with her family scampering after, to lead them where they will be secure. She does not stop till there is no fear of pursuit. She leads the way, and hastens on with an occasional grunt, which many indicate displeasure at being disturbed, or an admonition to her family to keep close. When she stops, they stop, and are as still as she. Though such matters must be new to them, and they can know little or nothing of the necessity of caution, the young things stand and listen as though they understood all about it. But onwards their mother

leads them, with a grunt as a signal for retreat, and she must be far from the spot where danger first menaced, and have reached the shelter of some protecting thicket, before she will stop or let her little ones stray at will.

"There is no peril that will daunt her when her young need defence. Her courage is then quite heroic. No matter who the spoiler be, whether man well-armed or brute of superior force, she flies at him with a fury which it is difficult to withstand. Nor will steady resistance or desperate wound keep her back or make her retreat. Not till her child be safe, or till she herself sink before her foe, does the combat end. For, as to driving her back, you might as well think of making a robbed lioness turn, as to expect her to cede, while life remains. And, as was said above, her bite is terrible; she tears out pieces of flesh, and tramples on her fallen adversary. She returns also to the attack, and does not wound in passing, and then go on, as the male animal will do. Hence, with her, it is useless to step aside, or get behind a tree, as you would, if the boar were to rush upon you; she is not to be evaded thus. When he attacks, and there is no other help, you may fling yourself flat on the ground, and you are safe, for the boar cannot wound downwards, but rips upwards only, as he passes and goes on. But she, were you to try such a stratagem with her, would turn it to her advantage and your sorrow; for you would never get up again whole and sound; may be, not rise at all. Yet the he and the she-boar, if let alone, will harm no one; on the contrary, they flee at man's approach."

The work contains matter for a lengthened review, which, however, our space will not afford; and those who are interested in the account of the Eagle, and the hairbreadth escapes of Eagle-hunters; or in that of the Boar, Roe, Deer, Cock of the Woods, &c., must purchase the volume, which they will find to be written is a very pleasing style, and illustrated with tolerably good wood-engravings and lithographs. The scientific information is meagre; indeed, the author states in his preface that it is wholly without scientific pretension.

SCIENTIFIC SUMMARY.

QUARTERLY RETROSPECT.

DURING the last month, the scientific world has lost one of its noblest and most useful denizens. We believe that in thus designating the late Consort of our Queen, we are paying a more just tribute to his memory than if we were to rank him amongst the noble patrons of science.

He was the noblest patron of science in the land, but he was also one of its most able and earnest devotees; and when his nobility shall be forgotten, his reputation as a man of intellect and a patron of mind will remain immortal.

Prince Albert attained to many posts of distinction during his lifetime; and it must be universally acknowledged that in every such case he occupied the position to which he was entitled by his intelligence.

He was the originator of Industrial Exhibitions in England, and for this alone any other man would have received a degree of homage, such as the Prince never sought nor accepted. He died Chancellor of one of our leading Universities; and in the year 1859 he was nominated to the highest scientific office that can be held by an Englishman; namely, the Presidency of the British Association for the Advancement of Science; and it is agreed, without a dissentient voice, that he acquitted himself honourably in this difficult and exalted position.

At various times we have been witnesses of the interest which he manifested in educational establishments of less pretensions than those referred to; and doubtless many of these will seriously feel his untimely departure, for it will assuredly be long before his place is supplied by his equal in worth and talent.

But let us not range ourselves by the side of those who see in his decease a cause only for regret and lamentation; nor be content to deplore and murmur over the loss that has been sustained by the country. Let us rather reflect how much better and happier he made the nation during his lifetime; what a favourable influence his modest usefulness must have exercised upon the minds of his children, who will have constantly increasing opportunities for well-doing; and let us take the lesson to heart, and consider how, surrounded by all the temptations of luxury, and of an exalted position, he prepared for himself, through a well-spent life, a smooth pillow for his last hours in a mortal state, and a happy home in eternity.

But another man of worth and talent has also recently departed this life. There are few living men who have done so much in the cause of science as the late Professor Quekett; and he too attained considerable eminence in his own sphere.

In 1856, he succeeded Professor Owen as Conservator of the Museum of the Royal College of Surgeons, but he only obtained this appointment at a time when his health was such as to render his promotion of little avail, and, indeed, too late to be of any service in ameliorating his worldly condition, or providing for his family.

Professor Quekett, like many more men of science, gave himself up for the world's benefit, and now leaves his offspring dependent upon the world of which he was the benefactor.

Two distinct committees are already formed to raise a memorial for his services; the one consists of Professors Owen, Busk, and other well-known men of science, and the honorary secretary is Lionel S. Beale, Esq. (King's College); the other was set on foot by the Microscopical Society, of which Professor Quekett was one of the founders, and Jabez Hogg, Esq., 1, Bedford-square, acts as secretary.

It is proposed that the money subscribed be invested in the hands of trustees to accumulate until the general education of the boys is complete, and they enter upon the profession or occupation of their choice, when a fourth part of the accumulated fund will be devoted to forwarding the interest of each in the manner which may seem most desirable.

We can heartily commend this object to such of our readers as are disposed to render a just tribute to a good as well as a talented man, and feel sure that the amount raised will be wisely husbanded by those who have the matter in hand.

The scientific progress of the last three months will be found recorded in the following papers :—

ASTRONOMY.

THOSE who have been charmed with the aspect of the heavens on a clear night, and the thousands of lustres which adorn this grand spectacle, should, at the least, show their gratitude by taking part, as far as lies in their power, in noticing the phenomena which are continually passing in those regions. We may particularly draw attention to such observations as can be made with the naked eye, as on the shape and dimensions of the Zodiacal light, at the ordinary extremity of which Goldschmidt detected a further very faint light the last few years; to the falling-stars and other meteors; to the Northern Lights; but more particularly to the stars themselves, and the changes of lustre which take place among them. This last subject is, indeed, one of the most interesting to which the attention can be directed in so far as regards amateur astronomy. When we look over a good celestial globe, or series of star maps, in which those objects visible to the naked eye are inserted, in order to find out the names and positions of the different stars and constellations, even during this primary instruction, we learn that the commonly-received notion of the existence of only six classes of stars visible to the naked eye is some-

thing very like a fiction, and that very few are exactly of the same brilliancy. Should the amateur arrange the stars visible without a telescope according to their brightness he would discover another remarkable phenomenon,—viz., that the stars are not equally constant in their light, but that many have been discovered to be variable; and it is very probable that many more remain to be detected, even of those visible to the naked eye. Thus, Beta of the constellation Perseus varies from the second to the fourth magnitude and back again in less than three days; Lambda Tauri changes nearly a magnitude in four days; Eta Aquilæ, in seven days; Zeta Geminorum returns to the same brilliancy every ten days; Beta Lyræ falls from the third to the fourth class, with singular changes of light, and returns to its original lustre every thirteen days; Alpha Herculis passes from the third to the fourth magnitude, and back again to the third every sixty-three days. Chi Cygni is visible to the naked eye at its brightest epoch, and almost unseen in the most powerful telescopes at its faintest time; it has a period of 397 days. In addition to those stars (all of which are easily found by help of a map of stars or a celestial globe), there are others which are visible at the present time, and on which many valuable observations might be made with unassisted vision, such as Epsilon Aurigæ, Alpha Orionis, Alpha Ursæ Majoris, Eta Ursæ Majoris, Alpha Cassiopeiæ, and Alpha Hydræ. Perhaps the most remarkable of all the variable stars is Omicron, or Mira Ceti, as it has been called, which has a period of 332 days. It is one of the brightest stars in the constellation of the Whale at its maximum brilliancy, being frequently, though not always, at that time of the second magnitude, whence it becomes completely invisible. Although favourably situated at present, it is now invisible without the assistance of a telescope, having arrived at its greatest brilliancy at the commencement of August, and being only visible to the naked eye for about 130 days. In addition to those objects, there are upwards of fifty well-determined telescopic stars which vary in lustre, more or less, and of which the following can be observed at present by those who possess telescopes:—T Hydræ (R.A. 8h. 48m., Dec. 8° 37′), with a period of 292 days, varying between the eighth magnitude and invisibility, arrives at its probable greatest brightness on Feb. 22, 1862; U Virginis (R.A. 12·44, Dec.+6°19′) will probably arrive at its maximum magnitude of the seventh order of brightness on Jan. 4, 1862; S Tauri (R.A. 4h. 21m., Dec.+9° 38′) will become visible on March 11, in *good* telescopes, when it arrives at its greatest lustre of the tenth magnitude. S Virginis (R.A. 13h. 25m., and Dec. 6° 28′) has a period of 368 days, and may probably become visible to the naked eye on May 15. R Tauri (R.A. 4h. 21m., Dec.+9° 51′) varies between the eighth magnitude and invisibility, will arrive at its maximum on May 7. U Capricorni (R.A. 20h. 40m., Dec. 15° 17′) with a period of 412 days, arrives at its maximum of tenth magnitude at the end of February, 1862. These, of course, are only a sample of the riches of this class of objects, and the amateur will find much pleasure in following up and noting their changes. And although he may not find the winter temperature very agreeable, still, however, our insular temperature will not descend to the degree of cold noted by Winnecke, whilst observing the variable stars last winter

at St. Petersburg, when the thermometer fell to 22° below zero of Fahrenheit's scale.

Babinet says, that every clergyman and every schoolmaster should be the possessor of a telescope, and occasionally give those under his care an idea of the inexhaustible riches of nature. It is only with that instrument that some of the above observations can be made; and until the optical millennium arrives many will remain ignorant of the appearances of the sun, moon, and planets; of the structure of the nebulæ; of the clusters and double stars. Some ingenious and inquisitive minds may wish, however, to construct an optic tube, through which some of the wonders of the heavens may be seen; and a German astronomer of note recommends the following as a cheap non-achromatic comet-seeker:—For the object-glass, obtain a plano-convex of two and a half inches in diameter and thirty inches focus. The eye-glass is constructed of two lenses. That nearest the eye would be of an inch in diameter and two and a-half inches in focus; and four inches from it, and between it and the object-glass, would be another of two inches in diameter and five inches in focus. The whole apparatus might be placed in a tin tube, blackened inside; the two lenses composing the eye-piece to slide in a separate smaller tube. This will give a field of four or five degrees, and magnify about ten times, and will show the stars in the Pleiades and the sword-handle of Perseus very well. It is to be remembered that, in an achromatic telescope, it is the object-glass which is the principal affair. Having obtained that, the purchaser can have the tube, eye-pieces, and stand, fitted up at his discretion. But it must be confessed that much care should be used in buying an object-glass, as a bad one, with its twirling and distorted images, gives much more annoyance than pleasure to the purchaser; and a good maker should accordingly be chosen for this most important part of the telescope.*

Encke's comet, after having been 390,000,000 of miles away from the sun, has returned to sight; and on Feb. 6, of 1862, will only be 32,000,000 of miles from that luminary. It may be seen with a small instrument, at the beginning of the year, by making use of a common star-map, with the lines of right ascension and declination marked as usual, on which the following places of the errant body are marked:—

	Right Ascension. H.	M.	Declination. DEG.	MIN.	
Jan. 1	22	17	3	7	North
„ 6	22	16	2	31	„
„ 11	22	14	1	39	„
„ 16	22	9	0	19	„
„ 21	22	0	1	52	South
„ 26	21	44	5	30	„
„ 31	21	17	11	1	„
Feb. 5	20	47	17	23	„

* To those who do not wish to try the *experiment* of constructing a telescope at little or no cost, we recommend a small instrument made by Messrs. Parkes and Son, Birmingham, the cost of which is less than £4. It is mounted upon a cast-iron stand, and sold in a convenient box. It has afforded us great pleasure—in enabling us to examine the more prominent objects in the heavens. There are doubtless other equally good and cheap instruments.

It has been known to be visible to the naked eye when nearest the earth. It was detected on the 23rd of October in America, by Bond, but might have been seen several weeks earlier. It was excessively faint in November, and its appearance bore out the idea of its almost ethereal nature, which a French philosopher describes as its bearing the same relation to the earth in weight as a fly to an elephant, and even adding a superlative to the lines—

"Quid levius plumâ? Pulvis—Quid pulvere—Ventus,
Quid vento? mulier—Quid muliere? Nihil."

It will astonish many to hear that the great comet of July is still in sight, but only the most powerful bodies can reach it. It is now in the constellation of Lyra. Its place, on Jan. 1, 1862, is 18h. 47m. R.A., and 49° 7′ of north declination.

The Sun has been covered plentifully with spots during the whole of the present year, but at the beginning of December they were especially in great number. On December 7 and 8, upwards of thirty could be counted, which were of all sizes, and one of which had a great latitude :—

The equatorial regions were quite clear, and the zone of the spots was very definite, and, as at this time of the year, arranged in a straight line. The bright streaks were very brilliant near the spots and edge of the sun.

An eclipse of the sun (in which about one-half of its disc will be hidden) occurs on the last day of the year, beginning at Dec. 31, 1h. 51m. P.M. at London, and ending at 3h. 51m. P.M. It is to be observed in Africa, where it is total, by the Moorish astronomers, who so carefully noticed the phenomena in the eclipse of July, 1860, in the same country. The transit of Mercury, of Nov. 11, was invisible in London and its neighbourhood, and appears to have been somewhat unfortunate in Europe, generally.

The attention of telescopic observers will mostly be directed to Saturn, whose ring will be invisible until Jan. 31, after which time it will remain in sight until May 17, when it again disappears. The mountains and atmosphere of Venus will, doubtless, also attract their gaze, and the varying bands and atmosphere, and the changeable lustre of the satellites of Jupiter, be also strictly watched. Venus arrives at its greatest evening brilliancy on Jan. 21, and will be at its greatest morning brilliancy on April 2. It is in conjunction with the sun on Feb. 25. The discovery of new planets and comets appears to have ceased lately, but will, doubtless, be resumed with the clear weather and dark nights of the coming year.

CHEMISTRY.

I. Pure Chemistry.—Although no very striking discovery has been made in this department of science during the last few months, many subjects of minor interest have been investigated, and results obtained which are of considerable value to the student of science. Foremost among these must be placed the researches of M. Stas upon the atomic weights. The experiments embodied in his paper have occupied several years; their object being to test the accuracy of the hypothesis that all the atomic weights of the elements are multiples of that of hydrogen. The complete memoir is, perhaps, the most important chemical paper which has ever been written; and in respect to the very ingenious processes devised by the author for avoiding all chance of error, the enormous labour attending the purification of the materials used, or the almost fabulous accuracy of the results when compared one with another, these researches of Stas will always be regarded as a masterpiece of analytical research. Were the memoir confined to the abstruse scientific point, the decision of which it has for its object, a more than passing notice of it would be out of place in the pages of a popular review of science; but, like many other investigations by a real master in science, the incidental matters touched upon are of the greatest interest and value to practical men. Stas is the first who has set to work in earnest to prepare absolutely pure materials on a tolerably large scale, and in this he has been beset with so many unexpected difficulties, that it is not too much to affirm that perfect chemical purity is a thing hitherto unknown. He gives the most minute instructions for the preparation of absolutely pure hydrochloric, nitric, and sulphuric acids, water, ammonia, chloride of sodium and potassium; metallic silver and lead; and by the careful details which he gives on this subject, and also by his tests for ascertaining the presence of impurity in any of the above chemicals, Stas has conferred a lasting benefit upon all scientific inquirers. Already we find that he has raised the standard of so-called purity in several manufacturing works, whilst photographers, as well as practical chemists, are applying his processes for the preparation of metallic silver and its nitrate for their own purposes. As a result of this laborious investigation, Stas has been led to the conclusion that there is no numerical relation whatever between the atomic weights of elementary bodies.

Dr. Andrews has published the results which he has obtained on exposing the non-condensable gases to the combined action of great pressure and low temperature. By employing the elastic force of the gases evolved in the galvanic decomposition of water as the compressing agent, he succeeded in reducing oxygen gas to $\frac{1}{300}$th of its volume at the ordinary temperature of the atmosphere, and subsequently effected the same object by mechanical means. The gases, when compressed, were always obtained in the capillary end of thick glass tubes, so that any change they might undergo could be observed. The pressures applied were only limited by the capability of the glass tubes to resist them, and, as a further means of effecting condensation, the gases were exposed, in their highly compressed state, to the action of a freezing mixture, which would reduce their temperature to $-106°$ Fahrenheit. By this means,

atmospheric air was reduced to $\frac{1}{675}$th of its volume; oxygen gas to $\frac{1}{814}$th of its volume; hydrogen to $\frac{1}{500}$th; and nitric oxide to $\frac{1}{680}$th. None of the gases exhibited any appearance of liquefaction, even in these high states of condensation, notwithstanding that their densities must have been but little inferior to that of water.

Professor Graham, in continuing his researches upon the diffusion of liquids, has discovered a new means of separating substances which have, with difficulty, yielded to the ordinary processes of chemical analysis. By allowing complex organic and inorganic liquids to *diffuse* through a parchment-paper diaphragm, he finds that they separate into two classes, which he terms *crystalloids* and *colloids*, the process of separation being called *dialysis*. By the dialytic method of analysis, arsenic has been removed from a complicated organic solution, soluble silicic acid for stone-preservation has been separated from the accompanying salts, and many other equally important but hitherto difficult separations have been with ease effected.

Some remarkable experiments have been performed by Dufour on the alteration in the freezing and boiling points of liquids. By preparing a liquid of the same specific gravity as water, but immiscible with it, small globules of water would remain floating about with perfect freedom of motion in the centre of the mixture. The medium employed by Dufour was essence of cloves, to which a few drops of oil had been added. By then carefully applying heat to this liquid, a temperature far above the boiling point could be attained without causing the ebullition of the globules of water; small spheres of water, of half an inch or more in diameter, being readily brought to a temperature of 300° Fahrenheit without alteration, whilst smaller spheres could frequently be heated to a temperature of 350° without entering into ebullition, although at this temperature steam has a tension of eight atmospheres. At these high temperatures the globules were as calm and limpid as at the ordinary temperature; but when carried against the side of the vessel, or touched with any solid body, an explosive formation of steam was the result. Similar phenomena were produced with other liquids, such as chloroform, &c. In a like way it was found that the freezing point of water could be retarded.

By cooling the medium in which the aqueous globules were floating in equilibrium, the water could be reduced to twenty or thirty degrees below the freezing point without solidifying. Ultimately they became suddenly converted into solid lumps of ice; and this change could always be effected in them by contact with solid bodies. As in the former experiments, this persistence of the liquid condition under severe cold is not confined to water: sulphur, phosphorus, and naphthaline, all present similar phenomena; and were it not for the difficulty in finding suitable media, it is likely that many other substances would be affected in the same way. It is likely that these researches will throw considerable light on the formation of hailstones, and many minerals which show traces of igneous fusion.

II. Applied Chemistry.—Gorup-Besamez informs us that ozone, when properly employed, is a most effective agent for restoring books or prints which have become brown by age.

His process is to place a bit of phosphorus in a wide-necked glass carboy,

and pour on it as much water as will nearly, not quite, cover it. The jar is then closed with a cork, and allowed to stand from twelve to eighteen hours. At the end of that time, the air in the jar is strongly impregnated with ozone. Then, without removing the phosphorus, or water, the engraving to be restored is moistened with water, and being rolled up, it is hung in the middle of the vessel by a piece of platinum wire, and left at rest. In a little time all the parts of the paper not covered by ink are rendered white; it is then removed, and carefully washed with water containing a little soda.

Our juvenile readers will, doubtless, feel considerable interest in some recent researches by Professor Plateau on the figures assumed by a liquid mass when the action of gravitation is removed; not, however, for the sake of the curious theoretical conclusions at which he has arrived, although these are very remarkable, as for a practical hint which his paper contains, and which they will doubtless not be slow to put into practice.

The Professor had discovered that some of the experiments, which he had hitherto been able to try only with great difficulty upon liquid media, inclosed in other liquids of the same density, could be readily performed in the air by forming the liquids into thin films; by converting them into "soap-bubbles," in fact. It was, however, necessary that some more stable kind of bubble should be obtained than the one with which we are all familiar, and which rarely lasts two minutes; and after much trouble the following liquid was prepared:—One part, by weight of Marseilles soap, previously cut into thin shavings, is to be dissolved by heat in forty parts of distilled water, and the mixture filtered after cooling. When this is effected, three volumes of this liquid are mixed, by violent and continued agitation, with two volumes of glycerine; it is then allowed to stand. The liquid, which is at first clear, begins in a short time to grow turbid, and after some days a white precipitate will be seen to have risen to the top of the liquid. Draw this off with a syphon, and preserve in a stoppered bottle for use. If a bubble be blown with this liquid, by means of a common tobacco-pipe, one may readily be obtained, four inches in diameter, and if this be supported upon an iron ring, one and a half inches across (previously wetted with the *glyceric liquid*), it will remain unbroken for three hours or more in the open air of the room; and for three days even, if protected under a glass-shade. There is a peculiar charm in the contemplation of these figures—so slender, almost reduced to mathematical surfaces—which make their appearance accompanied by the most brilliant colours, and which, in spite of their extreme frailness, endure for so long a time.

Analytical chemistry has recently done good service to the poorer inhabitants of London. It is known that, scattered about in different parts of the City, there are numerous pumps which generally possess a reputation in the neighbourhood for more refreshing, sparkling properties than are enjoyed by the water companies' supply. Dr. Letheby, as Medical Officer of Health for the City of London, has however dispelled all these pleasing illusions, and has disclosed the frightful state of the impurity of these much-admired drinking waters. He has been devoting much time to the chemical analysis of the water from these wells, and has shown that the coolness of the beverage and the briskness of its appearance are dangerous fascinations, for they are both derived from organic decay. Dead and decomposing matters have

accumulated in the soil, and have been partially changed by its wonderful powers of oxidation, and thus converted into carbonic acid and nitre; these have given to the water the agreeable qualities which are so deceptive. In reality, the water from the city pumps is far worse than that from the muddy river from which it is in great part derived; indeed, it may at any moment become charged with the active agents of disease; for no one can say when the salutary influence of the soil may fail by being worn out or over-taxed, and then the putrid organic compounds will pass into the wells unchanged. Many of the pumps are in close proximity to the fat graveyards of the City, and it is more than probable that all derive a portion of their waters from these sources, for they are the principal gathering grounds for the surface springs; in fact, they are the only open spaces through which the rain can percolate to reach the shallow wells. Besides organic matter, these waters contain large quantities of common salt, which clearly points to the presence of the filthiest contaminations from sewers and cesspools. It is the organic matter, however, which is most to be dreaded; the former are simply repulsive, but the latter is, or may be, fatal, for these organic corruptions in waters have frequently been proved to be, and may now become at any moment, the immediate cause of Asiatic cholera. This is no fanciful nor theoretical danger, for Dr. Letheby gives numerous instances in which this plague has attacked only those who used water from a certain favourite pump. In 1854 there was a sudden and serious outbreak of cholera in the parish of St. James, Westminster, and out of seventy-three persons who died during the first days of the visitation, sixty-one had been known to drink the water from a pump in the neighbourhood. Moreover, amongst persons in the same street, or even the same house, those only were attacked who employed this water, whilst others, who lived at a distance from the parish, and had the water sent to them because of its supposed goodness, were seized with cholera and died. Upon the attention of the authorities being drawn to this circumstance, the well was examined, when it was found that the neighbouring cesspool had leaked into the well, and had communicated to it its poisonous action. Several similar instances are quoted by Dr. Letheby, and it is stated that when the source of water was cut off by removing the handles from the pumps, the further spread of the epidemic was arrested. Out of all the wells examined, only two have been found at all fit for domestic purposes; the others contain an enormous amount of impurity, and in fact can only be regarded as so many dormant centres of cholera,—liable at any moment to break out into active pestilence. The subject of the deodorization of sewage has been very successfully taken up by the authorities at St. Thomas's, Exeter. Owing to an indictment for a nuisance occasioned by their sewage outfall annoying the servants and passengers of an adjoining railway, they were about to expend £1,200 in conveying the sewage to another point, when the attention of the local board was drawn to the successful use of carbolic acid, with which Mr. McDougal disinfects the sewage of Carlisle. After some discussion, they determined to adopt the same plan. The results are most satisfactory. At an expenditure of one gallon of carbolic acid per day, costing elevenpence, the whole of the sewage is completely disinfected, and this, not only in a temporary manner, but by the power of the agent in arresting decomposition, the sewage is prevented from subsequently becoming

putrescent; decomposition cannot afterwards set in, nor can any unpleasant gases be evolved. The valuable fertilizing properties of the sewage are likewise all retained, and in its deodorized form the liquid has been applied with the utmost success to the soil, producing better crops than had ever been known before.

GEOLOGY.

One of the most interesting of recent geological discoveries is that of the "Limb-lizard" of the lower Lias, a reptile equalling in size the largest known fossil forms. It is not however its size, but its structures, which are interesting, for naturalists are accustomed to believe that every group of animals, commencing with humble forms, lives on in time attaining higher organization; and though this example does not materially invalidate that view, it shows that reptiles existed near the beginning of the secondary age, of highest type, and equal in every way to the well known Iguanodons and Hylæosaurs which mark its close. This large land lizard is named by Professor Owen, *Seelidosaurus* and included in the order *Dinosauria*. The teeth of its upper jaw passed with scissor-like action in shutting the mouth, outside those of the lower jaw, just as they do in carnivorous mammals. In form the teeth were laterally flattened, triangular above the jaw, and notched at the sides, and so presented an aspect intermediate between that of the little existing Iguana tooth and that of the cretaceous fossil Iguanodon. It is towards this latter genus that the whole of its affinities tend, and, like it, it is regarded as having been herbivorous. The only part of the head which is wanting is the extremity of the upper jaw, and to this much interest attaches; for though the skull found shows that the nostril was not near the eye, as in the associated Ichthyosaurs, but at the extremity of the snout, it remains for the wanting fragment to determine whether it will be single, as in the crocodile, or double, as in lizards.

Very little is yet known of the Jurassic land reptiles. One of the undescribed forms from the Kimmeridge clay is a monster with solid limb-bones, and unguiculate feet, which could not have measured less than a yard in length.

Dr. Dawson has lately communicated to the Geological Society an interesting discovery in the coal measures of Nova Scotia, of a species of land-shell, in abundance, of the genus *Pupa*. It is found in the under clay containing the Stigmarian roots of the Sigillaria. The same species was again found more than twelve hundred feet higher up in the series, indicating that it had survived numerous oscillations in the level of the land, and the growth and decay of at least twenty forests. Of more importance than the duration of the species is the permanence of the genus, which is, in all essential points, the same that now lives abundantly in the grass of our meadows—a duration of time comprising at least three-fourths of all that geology makes us cognizant of, not having sufficed to produce in it a single change.

Figures and a description have recently been published in the *Geologist* of a piece of bone which the editor assures us is a spear-head. It is phosphatized, and was picked up on a heap of phosphatic concretions from the Reg Crag. It is certainly of Crag age. Should the discovery of other and less equivocal weapons prove the existence of man in the Pliocene period, it would raise interesting speculations on recalling the feature of the Hindoo mythology, in which the elephant, supporting the world, stands on a tortoise, to remember that *Chelonia atlas*, which could have supported one of the elephants, which existed with it, is found fossil in the newer Miocene.

Mr. Stoddart has discovered in the Carboniferous Limestone of Clifton, near Bristol, a stratum twelve feet thick, almost entirely composed of microscopic fossils. From one pound weight of the rock were obtained one million six hundred thousand distinct and perfect fossils, besides a large quantity of broken shells and other fragments. But what gives an interest to the circumstance, is the fact that a large proportion of these specimens are minute univalve shells, of a twentieth, thirtieth, and fortieth of an inch in length. These fossils are referred by the author to the genera *Pleurotomaria*, *Turritella*, and *Euomphalus*, though without any indications, either in the figures or descriptions, of the structures which characterize those genera.

Students of star-fishes will be interested to learn that those singular Silurian forms included in the genus *Protaster*, which so nearly resemble some of our British stars, having, like them, slender arms attached to a circular disc, and having a similar structure of those arms, have been shown by Mr. Salter to have on the under side a double row of pores for the protrusion of tentacle feet, as in the common asteroid star-fishes. There is thus, as also in many of the minor points of structure, a blending of the characters of the two great groups of free star-like creatures. It is from this circumstance that the discovery has great importance. It leads to the expectation that when the contents of the palæozoic rocks shall be better known, other forms will be found bridging over the gap, till now so wide, between the two orders.

It has lately been shown by Harry Seeley that in much of the central part of England the Coral Rag is replaced by a clay. This formation has been named the Tetworth Clay. Instead of containing the fossils of the Coral Rag, it has a mixture of those most characteristic of the Oxford Clay below, and of the Kimmeridge Clay above, so that the three formations hitherto included partly in the Upper, and partly in the Middle Oolite, are so linked together as to form one great formation which has received the name of Fen Clay, from its constituting the great Fen district of Cambridgeshire and the adjoining counties. By the discovery of rocks similar to the Kelloway, though of less thickness, the Oxford Clay has been divided by the same author into upper, middle, and lower. The most important of these stone bands is the Elsworth rock, a limestone fourteen feet thick, which he regards as the uppermost stratum of the Oxford Clay series.

MICROSCOPY.

WENHAM'S BINOCULAR MICROSCOPE.

THERE is no single instrument which has exercised such an important influence upon the advance of the sciences of anatomy and physiology, whether animal or vegetable, as the microscope. This invaluable aid to the otherwise limited power of the eye, has enabled us to peer inquisitively into the details of structure even of the minutest organisms, and to discover in them wonders and beauties, in the existence of which it would otherwise be hard to believe. The microscope is daily, under the eyes of numerous diligent observers, making discoveries of new facts, confirming sound conclusions, and exploding fallacious theories; and no scientific man can in this day expect to make either name or reputation, who does not call to his aid this powerful auxiliary. The physician, no less than the scientific zoologist and botanist, derives most important assistance from the microscope, and medicine can boast almost as great an advance as the collateral sciences. It is intended that the readers of the POPULAR SCIENCE REVIEW shall be kept informed of the principal discoveries made from time to time by means of the microscope, and the Quarterly Retrospect of Microscopical Science will have for its object to keep the reader *au courant* with the ever rapidly accumulating knowledge and information upon such topics.

Seneca, who wrote 64 A.C., tells us (Nat. Quæst. lib. i. c. 7) that "letters, though minute and obscure, appear larger and clearer, when seen through a glass bubble filled with water;" and here the ancients stopped; and although one would imagine that it would have been easy to make some sort of advance upon this phenomenon, yet not a step did they progress, although it is evident from Pliny (Nat. Hist. lib. xxxiv. c. 26), that they understood the art of grinding glass.

But it appears that for seventeen centuries the glass bubble suggested to no one the possibility of improvement, nor can it be said with certainty how the Dutchman, Drebbel, or the Italian, Fontana, to whom the invention is indifferently ascribed, happily succeeded in conceiving and executing a microscope, about the year 1621. A great rarity, and costly withal, was the microscope of that day; and we may safely infer that it was but a rude contrivance. In the middle of the same century, Van Leeuwenhoek improved upon it, and achieved a great reputation from his researches, the success of which arose from the care with which he polished his own lenses. The microscope used by this eminent anatomist consisted simply of a single lens, set between two plates of silver perforated with a small aperture.

Compound microscopes contain lenses having distinct functions: one to receive the rays from the object and bring them to a focus, where an image is formed, which image is examined by another lens in the same way that the object itself is examined by the lens of a simple microscope. It is such an instrument as this which, originally poor and imperfect, has received for many years the utmost care and attention of the optician, with a view to its improvement and perfection; with what results will presently appear.

The increased colouring and distortion of the image, arising from the increased distance it had to traverse, have gradually been overcome by corresponding care in the construction of achromatic glasses; and a series of improvements made during the last thirty years has culminated in an instrument, which for precision of adjustment and truth of definition has left scarce anything to be desired.

The optical wonder, which merits this encomium, is known as "Wenham's Binocular Microscope," so called because, instead of peering with one eye down a single tube, as heretofore, the observer has the additional comfort, convenience, and advantage of looking with both eyes down a pair of tubes, so exquisitely adjusted, that the object is accurately and beautifully defined by the combination. This is, perhaps, the perfection of microscopy, and the scientific world is deeply indebted to the well-known and remarkable skill and ingenuity of Mr. F. H. Wenham for this marvellous instrument. Like all great discoveries, the binocular microscope was not the result of a lucky accident or guess, but of patient investigation and unwearied labour, and a perseverance undaunted by failure.

The stereoscope, whose phenomena have so captivated the public mind, perhaps paved the way for the invention of a binocular microscope, for although the principles of the two instruments are dissimilar, the result arrived at was the same, viz.: to give to the object that aspect of solidity, which natural objects assume when viewed with our two eyes. The object of such a double arrangement of our visual organs being to enable us to see the same object under two aspects at the same time, these two aspects being separated by the distance between the two rays, but so combined in the brain as to produce a single image having an appearance of solidity. Now the difference between the stereoscope and the binocular microscope is simply this, that in the former we arrange two images in such a manner that we succeed in seeing them as they *are not*, whereas in the latter we succeed in arranging our two eyes, so that, looking at a single object, we see it as it really *is*—that is, relieved from the flatness which appears in objects viewed only with one eye. This, it will be seen at once, is an immense advantage, and Professor Riddell of New Orleans constructed an instrument which aimed at this result, but without practical success. Mr. Wenham then came into the field, but his first attempt, described in the second volume of "Microscopic Journal," N.S., was also far from attaining that perfection of adjustment and definition which was essential to success. France also put in a claim, and M. Nachet produced a microscope free from many of the defects of Mr. Wenham's first attempt; and for low powers this wonderfully cheap instrument answers admirably, losing, however, its clearness of definition when high powers are used.

The improved form of binocular, however, now introduced by Mr. Wenham, and which has entirely captivated all microscopical observers, does not essentially differ from his former instrument. The principal objection to that, was that the projecting portions of the object appeared sometimes to be depressed, and *vice versâ*. The essential principle in all binoculars, is to bisect the pencils of rays which emerge from a single objective, each half being magnified and sent up in a separate tube to the two eyes, and each half of course differing in perspective projection; the

practical result being, that the enlarged image has the appearance of being seen by both eyes at the same time, and at a sufficient distance to make them both useful.

In Mr. Wenham's former instrument, the bisected rays diverged when they passed the prism, so that the right-hand half of the rays reached the right eye, and the left-hand, the left. Applying, however, the fact known to stereoscopists, that the remedy for a transposition of the projecting and depressed part of the picture, when viewed through the instrument, was a transposition of the two stereoscopic *pictures*, Mr. Wenham transposed the images of his microscope, by so constructing the lens that the divided pencil of rays *con*verged, instead of *di*verging, crossing each other immediately above the objective, and thus passing, the *right*-hand half to the *left* eye, and *vice versa*, the result being *orthoscopic*,* instead of *pseudoscopic*,† as before.

The two eye-pieces are placed sufficiently near to suit those whose eyes are naturally near together, but by means of draw-tubes attached to them they may be made to diverge half an inch further, thus suiting all eyes. The chief advantage which this instrument possesses over that of M. Nachet, is that only a single refracting prism is used instead of a double system, as in the latter instrument, the definition under high powers being of course much more perfect the fewer deflections the rays have to undergo.

No one can fail to be struck with the beautiful appearance of objects viewed under the binocular microscope. Its chief application is to such objects as require low powers, and can be seen by reflected light, when the wonderful relief and solidity of the bodies under observation astonish and delight even the adept. Foraminifera,‡ always beautiful, have their beauties increased tenfold, vegetable structures, pollen, and a thousand other things are seen in their true light, and even Diatoms,§ we may predict, will receive elucidation as to the vexed questions of the convexity or concavity of their infinitely minute markings, so that both the scientific and dilettante microscopist may find work for the eyes, or food for the imagination. A very important and valuable scientific fact must not be overlooked; namely, the application of the binocular to anatomical investigation. Prepared microscopic injections exhibit under the ordinary microscope a mass of interlacing vessels, whose relation, being all on the same plane, it is not easy to make out with any degree of satisfaction; but placed under the binocular they at once assume their relative position. Instead of a flat band of vessels, we now see layer above layer of tissue; deeper vessels anastomosing with those more superficial; the larger vessels sending branches, some forward and some backward, and the whole injection assumes its *natural* appearance, instead of being only like a *picture*.

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* From two Greek words, signifying "straight," or true vision.

† From two Greek words, signifying "false vision."

‡ Foraminifera are lowly organisms belonging to the Rhizopoda, the lowest type of animals. They resemble "Amœba," (see article "Lowest Forms of Life"), but are protected by calcareous shells.

§ Objects of which the true nature, animal or vegetable, is not yet defined.

In conclusion, it should be remarked that the binocular form can be adapted to any single microscope, so that any one possessing a good microscope of the ordinary form can, for about seven pounds ten shillings, have it transformed, under the workmanlike hands of Messrs. Smith and Beck, into the magical instrument known as "Wenham's Binocular Microscope."

MINERALOGY AND METALLURGY.

The Dissemination of Gold.—Mr. Eckfeldt, the assayer at the United States Mint, at Philadelphia, publishes the following curious fact:—Underneath the paved city of Philadelphia there lies a deposit of clay, whose area, at a probable estimate, would measure over three miles square, enabling us to figure out the convenient sum of ten square miles. The average depth is believed to be not less than fifteen feet. The inquiry was started whether gold was diffused in this earthy bed. From a central locality, which might afford a fair assay of the whole, the cellar of the New Market House, near Eleventh Street, was dug out some clay at a depth of fourteen feet, where it could not have been an artificial deposit. The weight of 130 grammes was dried, and duly treated; it yielded one-eighth of a milligramme of gold, a very decided quantity, on a fine assay balance. It is computed that there are under Philadelphia 4,180 millions of cubic feet of clay, and that in it securely lies 126 millions of dollars' worth of gold.

Gold in North Wales.—From time to time there has been considerable excitement respecting the discovery of gold fields within the British Islands. At one period the Lead Hills caused much stir in Scotland; and the Wicklow gold washings gave rise to the appointment of a government commission. Devonshire was advertised as having "Pactolean streams," and the "fable of Colchis" was to be realized in Cornwall. The Clogan Mine, near Dolgelly, in Merionethshire, is however really producing considerable quantities of gold. In 1844, Mr. Arthur Dean read a paper before the British Association on the auriferous veins of this district. Since that period numerous trials have been made, but every such trial has resulted in great loss to the adventurous gold seekers. It is satisfactory now to know that gold is obtained from the Clogan Mine at a profit. Mr. Readwin gives the following statement as the result of the workings up to last September:—"207 tons 8 cwt. of quartz gave 1,314 ounces of fine gold; three tons of the best of this quartz gave no less than 976·6 ounces of gold. If they added 56 ounces obtained from 5 tons in 1860, it showed a total quantity of 1,370 ounces of gold from 212 tons of auriferous mineral, being at the rate of six ounces and a half per ton." The value of this British gold was £5,300.

The Gold of Nova Scotia.—Mr. O. C. Marsh, of Yale College, gives, in the last number of the *American Journal of Science*, an interesting account of this discovery. On the Atlantic coast of Nova Scotia is a belt of metamorphic rocks extending the whole length of the province, and varying in width from ten to fifty miles. It is mainly composed of clay-slate and quartzite,

but in some parts of the district these are replaced by mica-slate, gneiss, and granite. The general resemblance of these strata to the gold-bearing rocks in other parts of the world has been occasionally noticed; but it was not until March, 1860, that any discovery of gold was made in them.

Gold was then accidentally found in Halifax county, about fifteen miles from the coast, in the bed of a small stream which empties into the Tangier river. This precious metal has since been discovered at Rawdon and Douglass, in Hants county; Gold River, near Chester; and at Lawrencetown, a few miles east of Halifax. The quantity of gold as yet obtained has been, as compared with the produce of Australia or California, small; but the auriferous track appears to be very extensive. The Tangier gold, according to Mr. Marsh, gives—gold 98·13, with silver 1·76 grains; while the Lunenburg gold gives—gold 92·04, and silver 7·76.

Natural Oxide of Antimony.—The island of Borneo has, for some years supplied Europe with nearly all the sulphide of antimony it consumes. In connection with this mineral (the *stibine* of mineralogists) there has been found another, which was for some time rejected as useless. Upon examination, it has, however, been found to be a remarkably rich and pure oxide of antimony. Dr. Phipons has examined this mineral, and he identifies it with *stibiconise*, or the antimoniate of antimony. Whereas stibine seldom yields more than 45 per cent. of metallic antimony, the stibiconise gives above 65 per cent. of metal. This ore promises to become of great value, and it is now used as a pigment, being simply calcined and powdered, as recommended by Dr. Stenhouse in the following process:—The oxide is first reduced to coarse powder, and it is roasted for four hours, at a low heat, with free access of air, in muffles. The calcined product is then reduced to an impalpable powder, by being ground in flint-mills. This, when dried and mixed with oil, constitutes the paint. This paint has a delicate stone colour, is equal in body to white lead; it is devoid of anything hurtful to the workmen, either in its manufacture or use, and its price is considerably lower than that of white lead. One advantage of lead over every other mineral as a pigment must not be forgotten. Lead and its compounds enter into chemical union with oil, most other metals only mixing with it. This antimonial paint is said to be unaffected by sulphuretted hydrogen.

Nickel Coins.—We have recently been substituting, with many obvious advantages, a light bronze coinage for a heavy copper one. The Belgian government have passed a law deciding the future composition of their halfpenny, penny, and twopenny pieces. They are to be of copper, alloyed with 20 per cent. of nickel. This produces a white metal, and the coins are small, light, do not tarnish, and are without smell.

Steel Flowers.—The inventive powers of the ingenious are ever taxed to the utmost for the purpose of supplying the wants of capricious fashion. Of late, steel flowers, and other glistening ornaments, have been in vogue. Few of those who wear them suspect the source of the peculiar shining material which forms the surface. It is the common lead ore of our mines, the sulphuret of lead, or, in correct chemical nomenclature, the sulphide of lead.

Some varieties of this ore are remarkable for the way in which they break up into small brilliant particles. This is the ore employed by the artificial florist. We learn that many tons of this lead ore have lately been used in this country and in France for this apparently trivial purpose.

Lead Pipes.—The action of water on lead has not unfrequently led to very unpleasant results. J. R. Nichols, an American chemist of some standing, calls attention to the fact, that leaden pipes are most acted upon by the water flowing through them when they are bent at an *acute angle.* Whether this is due to a change in the structure of the lead, or to the mechanical action of the water at the point where it is made to turn, is not certain. The evidence, however, is satisfactory, that the lead is more rapidly corroded at these bends than in any other part. The public should, therefore, see that the plumber twists the pipes supplying houses as little as possible; and that where a turn is absolutely necessary he should be instructed to make it as gradual as the circumstances of the situation admit, at all times avoiding acute angles.

Artificial production of Crystalline Minerals.—H. Saint-Claire Deville has recently obtained, by the action of chlorhydric acid gas upon metallic oxides, heated in a platinum boat contained in a tube of porcelain: *stannic acid* in beautiful crystals of the same form as the native oxide; *titannic acid* in brilliant crystals of a blueish tint; *protoxide of manganese* in beautiful emerald-green octahedra; *specular iron*, in fine crystals like the Elba ore; and some others. Deville suggests that gaseous emanations, as, for example, chlorhydric acid, may play an important part in geological phenomena, and may conduce to the formation of many crystalline minerals in nature.

The Indian Coal Fields.—Very loose and imperfect statements respecting the quantity of coal in India have been put forth from time to time. Professor Oldham, Director of the Geological Survey of India, now, for the first time, furnishes exact returns for the last three years.

	1858.	1859.	1860.
	MAUNDS.	MAUNDS.	MAUNDS.
Raniganj Coal Field.....	5,917,000	8,949,600	8,559,097
Rajmahal Hills	219,000	843,000	1,222,860
Kurhurbari	4,000	108,182	275,256
Palamow	—	28,648	30,900
Sylhet Hills	22,319	32,498	—
Total in Maunds ...	6,163,319	9,961,928	10,088,113
„ in Tons	226,140	365,575	370,206

The other known coal-fields of India are very insignificant, and there appears to be no probability of ever greatly increasing the supply of fossil fuel in India.

The Rock Oils of America.—Considerable interest has been excited by the discovery of many remarkably productive springs of mineral oil in several

parts of America. At the present time, commercially productive springs are yielding their oils in New York, Ohio, Pennsylvania, Kentucky, and Virginia. Under the name of "Seneca oil," a petroleum has long been collected by the Indians from the Seneca Lake in New York, and sold in the towns.

In 1859, wells were sunk for the purpose of pumping petroleum in several parts of Pennsylvania, and they have been vigorously continued up to this time, many of the wells yielding ten barrels a day, and some even sixty barrels. Three hundred and forty-five wells are now bored in Oil Creek, Pennsylvania, the average production being fifteen barrels a day. According to one statement, we learn that 1,500 barrels are *daily* sent to New York, and according to another, "as many as 2,800 barrels had been put into the waggons at a railway station, near the springs, in a single month." Certain, however, it is that very large quantities of this mineral oil are obtained—that it is sold in its crude state in New York for twenty-five cents per gallon, and that when refined by distillation, it is extensively used for illuminating, and for lubricating purposes.

At Tidionte, in Warren county, on the Alleghany, seventeen wells are in operation; these are said to produce 10,000 gallons a day. At Mecca, in the eastern part of the state of Ohio, is a large tract of oil country. Considerable quantities are also produced from wells on the Little Kanawha river, in north-western Virginia. On the Thames river, in Canada West, the supply obtained from a large tract of country is extremely large. The oil wells are mere holes in the ground, about six inches in diameter. These holes vary very much in depth, some being not more than 10 feet deep, others from 400 to 500 feet. The phenomena produced upon opening some of those wells are singular. One opened at Tidionte spouted oil and water to the height of sixty feet.

These springs of petroleum in America are principally found in the coal measures, and are referred by many to a decomposition of the coal itself. Other authorities say, "They do not seem to be of vegetable origin, but to have been formed from the animal remains of the older rocks." These questions, however, require a more close investigation than they have yet received. Similar springs—certainly not so productive—have been found in this country, in Derbyshire and the Kimmeridge shales; and the Caithness sandstones are to a great extent impregnated with a similar product.

The ever-burning springs of naphtha at Baku, in Persia, are well known, and the Rangoon tar, as it is called, is now an important article in commerce. A reliable authority says, "At Rangoon, on one of the branches of the Irawaddy, there are upwards of five hundred petroleum wells, which afford annually 412,000 hogsheads of this peculiar hydro-carbon. Nearly the whole of this finds its way to this country, and is the source from which sherwoodole belmontine, and Price's paraffine candles are largely manufactured."

Kerosolene.—In the Great Exhibition of 1851, a peculiar coal, then named *Albertite*, was exhibited. There has been much discussion as to the true character of this mineral, and eventually it has its place tolerably well defined by its name, *Albert coal.*

By distilling this coal at a temperature varying from 600° to 890° F.,

an impure naphtha, called *Kerosene*, is produced. By careful redistillation, a very volatile fluid is obtained, called *Kerosolene*.

This is a colourless, nearly tasteless, highly refractive, inflammable liquid. When a phial full of kerosolene is grasped by a warm hand, the liquid gives off bubbles of vapour, which have a faint odour not unlike that of chloroform. The peculiar anæsthetic effect of this substance was first noticed, from its producing torpor on a workman employed to clean out a kerosene oil cistern in Boston. This property naturally attracted the attention of medical men, and the physicians of Boston are now employing kerosolene in the place of chloroform and ether, it is said, with the most satisfactory results. Beyond its value as an anæsthetic agent, this volatile liquid promises to become of great use in the arts.

PHOTOGRAPHY.

THE forthcoming International Exhibition has undoubtedly proved a stimulus for exertion among all classes of photographers, and these efforts are by no means restricted to the well-known operators of this country. We are given to understand that much space has been applied for on the part of intending foreign exhibitors, whose works will be brought into somewhat close competition with the artistic productions of our countrymen. The decision promulgated by the Royal Commissioners respecting the classification of these works of art with the mechanical drawings, models, and other illustrations of engineering science in the great building has been called in question, and warmly discussed by the several journals devoted to Photography, most of which have urged the claims of photographic artists in favour of being placed in companionship with the older and better recognized departments of fine arts. In answer to this natural and well-grounded complaint on the part of the photographers, the *Engineer* has replied by taking up arms in defence of the profession, and deemed it requisite to assert the high character of the decorative arts among the examples of which it is proposed to include the results of photography.

In reviewing the progress made during the last few months in the practice and applications of photography, the *Enamels* executed by the patented process of M. Joubert deserve to be mentioned among those of first importance. The specimens recently produced by this gentleman include examples of different styles of photography transferred to, and burnt into the vitreous surfaces of glass and porcelain, and these results are not confined merely to the imitation of the monochrome effects so well exhibited and always admired in the ordinary transparent photographs upon glass, but are equally well adapted to the representation of *colour* in subjects which have not hitherto been deemed susceptible of treatment by any previously known photographic process.

The method of proceeding usually adopted by M. Joubert is substantially the following:—A transparent positive photograph of the object to be represented is first prepared in the ordinary way, or any negative

picture can at once be made to furnish the *cliché*, as it is termed by the inventor, merely on printing by superposition. In order to prepare the glass or porcelain surface to receive its impression, it is coated with a layer of honey and gelatine or albumen, containing a certain proportion of a soluble chromate, and when dried is placed in close contact with the *cliché* of the subject desired. By the unequal action of the sun's rays consequent on exposing it to the light, the sensitive surface is differently affected, and the character of the preparation becomes so altered in those parts where the light has acted fully, that being now rendered quite dry and horny, it is incapable of retaining any of the powdered enamel colour which in the next operation is freely dusted over the surface. But in other portions of the design, where the chemical substances have been altogether protected, or only partially affected during the exposure to light, the glutinous character of the surface remains unaltered or becomes modified in proportion to the activity of the rays operating upon the sensitive preparation. It is then apparent that the plate, after exposure, will take the enamel colours more or less freely when this material in the state of fine powder is spread over the surface, and that by a judicious exercise of artistic skill it would be possible to modify not only the depth of tint produced by one and the same pigment, but also to apply different enamel colours over the several portions of the picture, and so obtain all the requirements of a coloured photograph on the same plate. It remains, finally, to burn in and develope the colours applied to the glass surface by a carefully conducted furnace treatment, which will also have the effect of destroying the organic substances originally employed in the preparation.

The discussion relative to the *composition of the photographic image* has been again revived by Mr. Malone, at the London Photographic Society. The lecturer referred to the experiments of Scheele, Mulder, Hunt, and Spiller, and to the corroboration afforded by his own experimental results in support of the view which attributes to sunlight the power of decomposing the chloride and similar compounds of silver into their component elements, the reduced metallic silver being liberated in so finely divided a condition that the dark shades of colour observed in the photograph were accounted for by the feeble light-reflecting capacity of these minute particles, and that the different tints obtained were solely dependent upon slight variations in physical structure, and had no reference to chemical composition.

The *mounting of photographs** recently formed the subject of an interesting paper, read by Mr. G. Wharton Simpson, at a meeting of the South London Photographic Society. After referring to the artistic and general considerations which should be kept in view when proceeding to mount a photographic print, the author treats of the relative efficiency and permanence of the several adhesive materials ordinarily employed in the operation of mounting. Enumerating the following substances—gum arabic, starch, dextrine, albumen, glue, gelatine, and isinglass, and for special purposes india-rubber paste prepared either with benzole or

* Or *photograms*, as they have recently been called.

chloroform—Mr. Simpson gave the preference to newly-made starch paste as being the most suitable on account of the rapidity with which the fresh paste may at any time be produced in a state fit for use, with such facility, indeed, that no inducement was offered for the employment of a sample which had become tainted and acid by long keeping.

With reference to the applicability of certain kinds of *stained glass for photographic use*, the employment of the Spectroscope appears to have done good service in the selection of suitable varieties. Mr. Crookes has reported the experimental results obtained in the examination of a series of samples, whereby, in the case of orange glass, great differences were observed in regard to their power of intercepting the active photographic rays, which by the unassisted ocular inspection were quite inappreciable.

Photography on Phosphorus.—Dr. Draper has recently published a curious process: he forms a thin sheet of phosphorus by melting it between two glasses; this is exposed to the light, and is stated to become red. Dr. Draper appears to have produced on this phosphorus plate good impressions of the solar spectrum, with all the fixed lines very faithfully delineated. Some of these prints have been preserved for many years.

This has been claimed as a new discovery; but Böckman more than half a century since found that by exposing phosphorus in nitrogen to sunshine, there was deposited upon the side of the glasses, nearest the light, a red powder. He also discovered that a stick of phosphorus, exposed to the action of the solar spectrum, was bleached by the blue and violet rays, whilst it became red under the action of the red rays.

PHYSICS.

ACOUSTICS.

Musical Notes.—Professor Zantedeschi has for some time been engaged in acoustic experiments. He has published no less than nine papers on the subject in the *Sitzungsberichte*, of Vienna. The principal object of the author has been the determination of a fixed note, to which, as to an invariable unit of measure, the notes of different instruments may be referred. He informs us that the number of vibrations per second which produce the note C is from 272 to 276 at St. Petersburg, 271 in Naples, 268 in Milan, 266 in Venice, and 268 in Vienna. Lissajous states that in Paris the number of vibrations of the note A was 898 in 1856; while Sauveur informs us that in 1715 it was only 810. Professor Zantedeschi attributes this to a molecular change, gradually developed in the steel of which tuning-forks are made. In order to eliminate this source of error, he proposes to substitute for the tuning-fork a pipe such as is used at the present time by tuners of instruments in the south of Italy. He compared a number of tuning-forks and pitch-pipes known to be more than fifty years old, and found that the former had become higher, though unequally, when compared with the latter. In order to secure the fixity of a note, Zantedeschi considers that it should be

compared with the "syren" of Cagnard de la Tour, or with the toothed wheel of Savart. By these means, especially when combined with improvements suggested by M. Zantedeschi, the stability of the note, or the amount of its error, may at any time be ascertained. In France, the A has been lowered from 890 to 870 vibrations.

Zantedeschi does not appear to be aware of investigations of, and the beautiful instruments for, determining the vibrations of a note, invented by Professor Wheatstone.

Actinism, or Chemical Rays.— M. Niepce de Saint Victor has been zealously continuing his researches on the absorption of the chemical principle of the sun's rays. He gives a very instructive result in proof of this absorbtion. An unglazed piece of porcelain (*bisque*) is exposed to sunshine, one-half of it being protected from solar influence by an opaque screen; it is then taken into a dark room, and a piece of photographic paper is placed above it. This paper is blackened over all that part which is opposite to the solarized portion of the porcelain, whereas no change is produced upon that division which corresponds with the unsunned part of the plate.

ELECTRICITY AND MAGNETISM.

Musical Sounds produced by Electricity.—Mr. George Gore has devised the following beautiful experiment:—

A circular pool of mercury, from one to three inches diameter, is formed in a circular vessel of glass or gutta-percha; this is surrounded by a ring of mercury about one-eighth to one-tenth of an inch wide, and both are covered to the depth of about half an inch with a rather strong solution of cyanide of potassium. The pool of mercury is then connected by a platinum wire with the positive pole of a powerful voltaic battery, and the ring of mercury is connected with the negative pole.

The connection being completed, the ring of mercury becomes covered with crispations or elevated sharp ridges, about one-sixteenth of an inch asunder, all radiating towards the centre of the vessel, and a definite or musical sound is produced capable of being heard, on some occasions, at the distance of forty or fifty feet. The loudness of the sound appears to depend greatly on the power of the battery. If the battery is too strong, the sounds do not occur; and they are prevented by using the solution of the cyanide in too concentrated a state.

Magnetism.—Professor Wiedemann has been engaged in an inquiry on the relation between the magnetic and the mechanical properties of iron and steel. Amongst many exceedingly curious results, he has obtained the following:—

If an iron wire be twisted during or even after the passage of a voltaic current through it, the wire becomes magnetic. When the wire is twisted in the manner of a right-handed screw, the point at which the current enters becomes a south pole; in the opposite case it becomes a north pole. If, during the passage of the current, the wire be twisted in different directions, the polarity changes with the direction of the twist. If twisted in different

directions after the interruption of the current, the magnetism produced by the first twisting diminishes rapidly.

If a voltaic current be transmitted through a magnet in the direction of its axis, the magnet will twist.

The Dip of the Needle in London.—General Sabine has shown that there has been a gradual diminution of the dip in this city during the last forty years. The following table shows the rate at which this has been going on :—

1820	70° 07·3
1830	69 39·6
1840	69 11·9
1850	68 45·9
1860	68 19·9

Lunar Radiation.—Professor Tyndall, by means of a thermo-electric pile, has been engaged in measuring the temperature of the moon's rays. These observations were made from the roof of the Royal Institution, Albemarle-street. When the thermo-electric pile was directed *off* the moon, the needle oscillated between 10° and 20°, its mean position being 15°. When the pile was turned *on* the moon, the needle oscillated between 35° and 45°, the mean position being 40°. The following results were subsequently obtained :—

MEAN DEFLECTION.

OFF THE MOON.	ON THE MOON.
15°	40°
27	40
33	40

"These numbers all show *cold*, the deflection being such as would be produced by the cooling of the face of the pile presented to the heavens ; and the result is, that *the chilling was in all cases greatest when the pile was directed towards the moon.*" These results are not in accordance with those obtained by Professor James Forbes some years since.

HEAT.

On the Propagation of Heat in Gases.—Dr. Tyndall has been for some time engaged in the investigation of this subject. The researches of Melloni will be remembered, but Dr. Tyndall has considerably extended the inquiry. Sulphuric ether has been found to offer the most energetic resistance to the passage of radiant heat ; and the bi-sulphide of carbon to be least effective. Aqueous vapour also prevents the permeation of the dark heat rays. In a fine day in November, the aqueous vapour in the atmosphere produced fifteen times the absorption of the air itself. Variations in the quantity of vapour in the atmosphere would, therefore, necessarily produce corresponding variations in climate.

Magnus is also engaged in a similar inquiry, and has communicated a memoir on the subject to the Royal Academy at Berlin. As the investigations are still in progress, we shall defer any consideration of the subject until the investigators have made further advances.

LIGHT.

The analogy between the electric and sun light has been shown in a striking manner by Hervé Mangon. It is well known that plants grown in darkness, or exposed only to artificial light, are deficient in their green colouring matter; and it has always been considered that the sun's light is essential to its development. Mangon has now proved that the green matter is equally capable of being produced under the influence of the electric light. Availing himself of a powerful magneto-electric light worked by a small steam-engine, he exposed several flower-pots, each containing four grains of rye, for about twelve hours a day during five days, to the rays of the lamp. The grains, when exposed, had just sprouted, but showed no appreciable green tips. They were placed about a yard from the charcoal points, and were carefully protected during the whole of the time from external light. On the fifth day the experiment was brought to an end, when it was found that all the plants were as perfectly developed as if they had been in the open air, and all exhibited their natural green colour, and were strongly inclined towards the light. Corresponding seeds, grown in darkness for the same time, grew up perfectly yellow.

METEOROLOGY.

"*On the Distribution of Aqueous Vapour in the Atmosphere*," is the title of a paper read before the Royal Society by Lieut.-Colonel Richard Strachey. In all our recent meteorological observations, it has been the practice to separate vapour pressure from the pressure of the dry air, under the impression that the quantity of water vapour in the atmosphere influenced its pressure, as shown by the height of the barometric column. To determine the correctness of this practice, Colonel Strachey examines the hypothesis of Dr. Dalton, the observations of Dr. Hooker in the Eastern Himalaya, those of Mr. Welsh in his balloon ascents, and those by himself in Kumaon on the Himalaya, at heights varying from 1,000 to 19,000 feet above the sea-level. The quantity of vapour rapidly diminishes in the higher regions, consequently the ratios of the observed barometric pressures should be widely different at various elevations. This is not found to be the case. We must refer inquirers to the paper itself. Colonel Strachey's conclusions are thus given:—

"Now, it follows, from an obvious mathematical law, that the entire quantities of vapour in these different cases are inversely proportional to the constant reduction of density; so that the quantity on Dalton's hypothesis, which is that represented by the observed tension at the surface, is to the quantity according to Dr. Hooker as sixteen to four, and to the quantity according to Mr. Welsh as eighteen to four—a result nearly identical with the former. *The subtraction of the observed tension of vapour from the total barometrical pressure, in the hope of obtaining the simple gaseous pressure, must consequently be denounced as an absurdity; and the barometrical pressure thus corrected, as it is called, has no true meaning whatever.*"

The Winds.—Mr. James Glaisher, F.R.S., has just communicated to the Meteorological Society a paper on the duration of the winds in each month of the year. From 1841 to 1860, Mr. Glaisher obtains entirely reliable information; before that time the observations were defective.

It has been found that the prevailing direction of the wind from 1841 to 1847 was S.W. for three months, N.W. for a month and a half, N.E. for one month, in each year; and that there was no instance of a prevailing wind from the N.W. or E. in those years during any one month. From 1848 to 1856, the prevailing winds were S.W. for four or five months generally. In 1857, it was prevalent for six months; in 1854, for seven months and a half; but in 1855, for three months only; whilst N.W. wind prevailed from two to three months, and the N.E. from two to three months also. The N.E. in 1853 was prevalent for four months; in 1855 for six months and a half; and the W. wind was prevalent for one month in the years 1851 and 1853. From the year 1857 the S.W. wind has prevailed for eight months in the year on the average. In the year 1851 it prevailed for ten months; the N.W. wind being prevalent about one month, and the N.E. about two months; while in no instance was the N. wind prevalent for any month.

ZOOLOGY AND BOTANY.

AT the suggestion of Professor Owen and of Mr. Panizzi, the Trustees of the British Museum have decided to remove the Natural History collection from that institution. It is not yet decided in what building or locality it will be deposited.

The Ray Society.—Dr. Carpenter's work on the Foraminifera, which will embrace a general account of the structure and functions of those animals, is in the press, and will be shortly issued to subscribers for 1860. The botanical subscribers will also be glad to learn that for 1861 there will be issued a translation by Mr. Conway of Dr. Hoffmeister's work on the Higher Cryptogamia. This work will have all the value of a new edition, as Dr. Hoffmeister has supplied much new matter, and also additional plates. This will be a really most valuable addition to our botanical literature. The other works announced to follow are Dr. Bowerbank on the British Sponges; Mr. Blackwall, a second part on British Spiders; Dr. Gunther on Indian Reptiles; and Mr. Douglass on the British Hemiptera Heteroptera. We must, however, express our doubts of the wisdom of the step which plunges the Ray Society into the fearful mazes of technical entomology. To the naming of insects there is truly no end.

Mr. Van Voorst has just issued a third edition of Professor Rymer Jones's "Outline of the Animal Kingdom." It contains much new matter, upwards of twenty-five new plates, and is still undoubtedly without a rival in our language on the subject of Comparative Anatomy.

Many of our readers will recollect the advent of the Siamese Ambassadors to England. They brought with them several chests of Siamese products, as examples of what Siam could sell. These were carefully deposited in the cellars of the Foreign Office. During the last summer they gave off unpleasant reminders of their existence, and the authorities at once ordered the chests down to South Kensington. Here, in company with several similar presents from Japan, they are now to be seen. A large number of

the contents of these chests found a fitting locality in the Food Museum. They consist of dried fishes of curious shapes, of all forms of Holothur adæ (Sea-Cucumbers), known as bêches de mer, of dried cuttle-fish, and various forms of marine mollusca, of turtles' bones, elephants' trunks cut up ready for soup, rhinoceros-hides for ditto, curiously shaped and cut seaweed, dirty-looking confectionery in great variety, fruits and seeds in great variety unknown to English botanists. These, in conjunction with the collection of Chinese food which has been in the Museum so long, form a very interesting illustration of the department of National Foods.

It may interest many of our readers, who will visit the Great Exhibition of 1862, to know that a collection of samples of raw produce, imported into Liverpool, will be sent up from that town for exhibition. In 1851 such a collection was prepared by Mr. T. C. Archer, now Director of the National Museum of Scotland. This is now placed at the disposal of the local Exhibition committee, by the Liverpool Town Council (to whom the collection belongs), and two gentlemen engaged in business in Liverpool have undertaken to add specimens of all new and important importations since 1851, and to supply others, imported before that date, but which may be wanting in the old collection.

Dr. Wight, the distinguished Indian botanist, has written a series of letters in the *Gardeners' Chronicle*, giving the result of his experience as director of the experimental farms for the culture of cotton in India, under the sanction of the late East India Company. He enters into the details of the methods of culture adopted in India, compares them with those of America, and points out that the American system could not be introduced into India on account of its exhausting the soil, and requiring new regions for its extension. He shows that the Indian system is one of a permanent character, and that maintains the integrity of the soil. He is of opinion that, if cotton is cultivated on sound principles, it can be as certainly produced in India as any other crop, and that eventually it will be a more reliable source of this product than other part of the world.

The Gorilla controversy has almost lost its interest. It is now pretty well understood that M. du Chaillu has not been educated a naturalist, and that in attempting to impart an air of romance to his narrative, he has given a colouring to his descriptions which is not strictly correct. Some of his critics think that he was unfortunate in finding friends in England, who by their injudicious eulogies awakened the envy of those who are ever ready to depreciate qualifications which can never be their own ; and there is no doubt that some of these have been guilty of the very vices which they lay to the charge of M. du Chaillu. Dr. Gray, who, of course, is *not* to be reckoned amongst these, being a man who can afford to give credit to those who deserve it, has been his most bitter opponent ; and we confess that whatever may be the doctor's "turn of mind" in criticism, we consider that great credit is due to him for having stemmed the current of public opinion, and drawn the attention of those who are not carried away by the tide of popular applause to the fact that the "traveller's tales" should be taken *cum grano salis.*

His criticisms called forth vehement assertions of innocence from M. du Chaillu, who referred to two ministers of religion as witnesses to the truth

of his statements, and declared that he should procure from them, and publish, a verification of his narrative. We notice that he is said to have received their replies to his application, but they have never been published. On the other hand, witnesses have come forward to prove that his journeys, said to have occupied several months, could not have taken as many weeks.

How much of this is true, we are unable to say; but, after comparing his works with those of Dr. Livingstone, and carefully weighing the testimony of the participators in this controversy, we can only regret that so enterprising an adventurer should have injured his own reputation, and have done such mischief to the cause of science generally, as he has done by not adhering to a narrative of his adventures and discoveries, which would bear the strictest investigation.

Professor Owen has published his views on the Origin of Species. They differ from those of Darwin chiefly in the nature of the causes by which species have been produced; and especially in acknowledging a Divine Author of the laws, by which he conceives all forms of life to have been developed.

GENERAL SCIENTIFIC NEWS.

The Royal Institution of Great Britain has published the programme of its lectures for the ensuing season. Professor Tyndall commences the Friday evening lectures, with one on the Transmission of Heat through Gases. Professor Rollestone, of Oxford, gives a lecture on the Affinities and Differences between the Brain of Man and the Brains of certain Animals. * This will probably open the question of the amount of difference between man and the gorilla. The Age of Man follows, in a lecture by Professor Huxley, on the Fossil Remains of Man. Mr. Denham takes up the interesting subjects of Sleeping and Dreaming. Mr. Obin, Professor of Botany in University College, delivers a lecture on the Distribution of Plants. Dr. Odling will explain the nature of Professor Graham's Researches on Dialysis; and Mr. Savory lectures on the Motions of Plants and Animals. Although not announced, we believe we are correct in saying, that Professor Faraday will deliver a lecture before Easter; the juvenile course is this year being delivered by Professor Tyndall. It will be a great disappointment to many to lose their old favourite; but we think the young folks must regard themselves as fortunate in having so able a successor to Professor Faraday as Professor Tyndall.

Sir Benjamin Brodie has resigned the presidency of the Royal Society, and Major-General Sabine has been elected in his place. At the annual meeting of the Society on St. Andrew's-day, one of the Society's medals was given to Dr. Carpenter for his physiological writings, and another to the distinguished Swiss naturalist, Louis Agassiz, for his works on natural history.

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* Some persons may be puzzled to know to *what* animals Professor Rollestone refers.

The death of Professor Quekett made a vacancy in the curatorship of the Hunterian Museum at the College of Surgeons. Several distinguished men have come forward as candidates for the vacant post, which has not yet been filled up. We have already referred to the unfortunate circumstances which aggravate the loss of Professor Quekett, and commend the subject to the consideration of our readers.

The candidates for examination for science certificates at the annual examination of the Science and Art Department, in November, were more numerous than in 1860. A great increase has taken place in the Department of Natural History. In animal physiology and zoology, upwards of thirty candidates were examined, whilst in vegetable physiology and systematic botany there were seventeen. These numbers are against six altogether, who presented themselves in the two previous years.*

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* The contributors to our Quarterly Retrospect and Summary (the perfecting of which engages our earnest attention), are, at present, Mr. James Breen; Dr. Cuthbert Collingwood, B.A., Oxon; Mr. William Crookes, F.C.S.; the Editor; Mr. Robert Hunt, F.R.S.; Dr. Lankester, F.R.S.; Mr. Harry Seeley, Woodwardian Museum, Cambridge; and Mr. W. C. Unwin, B.Sc.